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Movement and habitat use of the largescale sucker (Catostomus macrocheilus) in the Clark Fork River Montana

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Movement and Habitat Use of the Largescale Sucker (*Catostomus macrocheilus*) in the Clark Fork River, Montana

by

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Movement and Habitat Use of Largescale Suckers in the Clark Fork River, Montana (81 pp.)

Chairperson: Andrew L. Sheldon Andrew L. Sheldon

The largescale sucker *Catostomus macrocheilus* Girard is native to the rivers and lakes of the Pacific northwest. Where found, it is often the most abundant fish in a watershed, with over 20,000 largescale suckers per river kilometer in reaches of the Columbia River. Very little is known about the basic ecology of this species; only one life-history is published. To determine movement and habitat use of largescale suckers in the Clark Fork River, and to estimate the influence that Milltown Dam has on these movements, I implanted radio transmitters into 38 fish collected within 17 km of the dam. In addition, in order to further assess spawning migrations and the spawning population structure, I conducted a three-year mark and recapture study of spawning largescale suckers at Milltown Dam. From the mark and recapture study, I estimated that in excess of 40,000 largescale suckers attempted to swim upstream of Milltown Dam during the spring of 1998. However, largescale suckers are most likely non-annual spawners, and this estimate may represent only 25-50% of the adult population immediately downstream of the dam. The influence of Milltown Dam on fish movement is significant. Two largescale suckers with radio transmitters made migrations to Milltown Dam in excess of 100 km. Movements of migrating largescale suckers captured at the dam were positively correlated with water temperature but not with river discharge. During non-spawning seasons, mean home range for ten largescale suckers with radio transmitters was 350 m and rarely exceeded one pool-riffle sequence. Maximum hourly movements occurred at dusk and at dawn. Fish moved from deep pools during the day into shallow, rapid riffles at night. Largescale suckers were found in Rattlesnake Creek feeding on mountain whitefish *Prosopium williamsoni* eggs and may have moved into the creek in anticipation of the mountain whitefish spawn. Although often considered a sedentary species, largescale suckers moved within a number of spatial and temporal scales, demonstrating the importance of an intact watershed that can support these movements and some of the consequences incurred when these movements are restricted.

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Acknowledgments

For the purpose of style, I have hesitantly refrained from using the pronoun "we" when describing work completed during this project. Thanks to my committee members, Dr. Andy Sheldon, Dr. Carl Heine, Dr. Don Potts and Don Peters. My advisor, Dr. Sheldon, has given me tremendous support throughout the project. The project was funded by Montana Power Company. Many thanks to their senior fisheries biologist, Brent Mabbott, and the operators of Milltown Dam, Guy Engebretson and Ken Estep. I am extremely grateful for the support provided by the entire Montana Department of Fish Wildlife and Parks Region Two fisheries staff. Don Peters agreed to channel my funding through his department and ended up devoting a significant portion of his staff's time to my project. In particular, Tim Swanberg and David Schmetterling taught me a great deal and spent more time looking for largescale suckers than either had probably envisioned. I owe much to many field assistants, particularly Craig Podner, for volunteering time to this project. Finally, my wife, Andrea Stephens, and our as yet unborn baby deserve the most credit for love and for an already impeccable sense of timing, respectively.

Semper catostomus.

Introduction

The largescale sucker *Catostomus macrocheilus* Girard is the most abundant fish in many of the large rivers and lakes in the Pacific northwest (Scott and Crossman 1973) (Figure 1); 23,000 largescale suckers are present per river kilometer in sections of the Columbia River, WA (Dauble 1986). Despite this abundance, virtually nothing is known about the basic ecology of this species. Like many catostomids, the largescale sucker is more often targeted for removal (Wiley and Wydowski 1993; Jenkins and Burkhead 1993) than for study. Only one life history of the largescale sucker, Dauble 1986, is published. Other brief publications pertain only to lake populations (McCart and Aspinwall 1970; Macphee 1960).

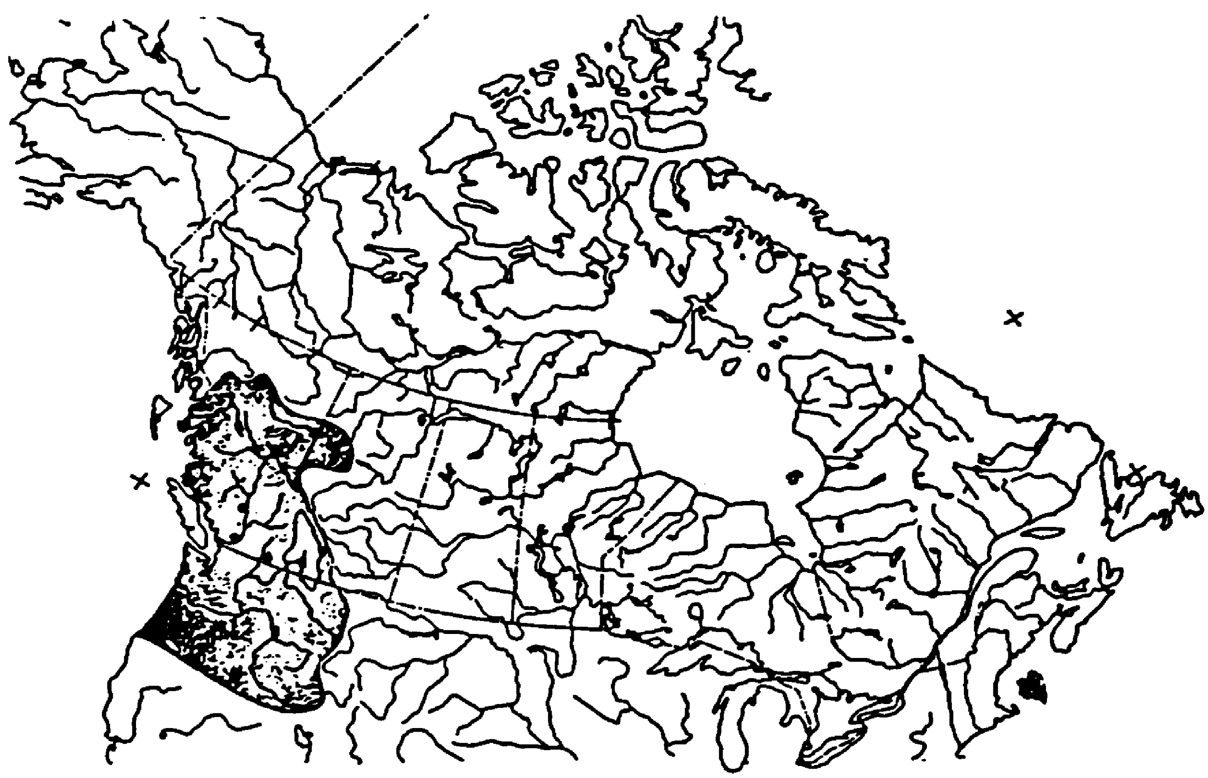


Figure 1.- Distribution of largescale suckers.
(From Scott and Crossman 1973)

Although Mathews (1998) writes, "movements and home ranges of fishes have been very well studied, with dozens of books and hundreds of publications addressing patterns for individual species," movements of many non-salmonid (and often non-game) inland riverine fishes such as largescale suckers are rarely studied and are poorly understood (Tyus 1990; Lucas and Frear 1997). This is particularly relevant in the Pacific northwest, where most fisheries study is directed towards commercially important migratory salmonids (Li 1988; Gadomski and Barfoot 1998). Yet non-salmonid fishes, particularly catostomids and cyprinids, often dominate the fish biomass of North American rivers. Nevertheless, only one radio-telemetry study, Matheney and Rabeni (1996), has been published describing movements of riverine catostomids.

The relative paucity of radio telemetry studies of non-salmonid fish is significant, because use of radio telemetry permits detection of movements in large rivers typically missed by more traditional mark and recapture methods (Gowan et al. 1994; Young 1996; Lucas and Batley 1996). The few recent radio telemetry studies of cyprinids and catostomids, for example, have demonstrated unexpected and often extensive movements within a number of spatial and temporal scales. Longitudinally, adult barbel *Barbus barbus* and Colorado squawfish *Ptychocheilus lucius* make extended spawning migrations of twenty to 200 km (Lucas and Batley 1996; Tyus 1990). Laterally, Colorado squawfish and northern hog suckers *Hypentelium nigricans* move into flooded riparian areas during catastrophic flows to avoid high discharges (Tyus 1990; Matheney and Rabeni 1996). Temporally, northern hog suckers make surprising movements into fast riffles at night to rest (Matheney and Rabeni 1996).

By detecting numerous movements of individual fish, studies using radio telemetry have highlighted the importance of an intact watershed that can support these movements and the consequences incurred when these movements are restricted (Lucas and Batley

1996; Martinez 1997). River obstructions such as dams alter patterns of movement by limiting or preventing extensive longitudinal movements and by altering the hydrodynamics of the river (Minckley 1991; Martinez et al. 1994; Mathews 1998). The former effect has contributed to significant declines in migratory salmonid populations by restricting access to spawning tributaries (Mills 1989; Lucas and Frear 1997; Swanberg 1997). For many fish species that do not require tributaries for spawning, the latter effects of dams can be as deleterious. For example, as a result of changes in both the hydrology and ichthyofauna secondary to damming of the Colorado River, razorback suckers *Xyrauchan texanus* have not had successful recruitment into the population for 45 years (Minckley et al. 1991).

While populations of largescale suckers are often large, little is known about this species' movement and habitat requirements. Mark and recapture studies have provided some information of movement and habitat use; Dauble (1986) characterized the Columbia River population as "highly mobile," with some fish moving in excess of 60 km. The effects of dams on these populations is similarly unknown. However, from 1970-1980, largescale sucker passage over the Priest Rapids Dam on the Columbia River has declined from 100,000 to 20,000 fish per year (Dauble 1986).

Each spring in the middle Clark Fork River near Missoula, Montana, tens of thousands of largescale suckers migrate upstream to Milltown Dam. The presence of this quantity of fish suggests that at least a portion of the largescale sucker population is highly mobile and may be impacted by the dam. This study uses radio telemetry to assess migratory and other movements as well as the habitat use of largescale suckers near Milltown Dam. However, because radio telemetry can only reveal characteristics of a small portion of a large population, this report combines with telemetry a three-year mark and recapture study of spawning fish at the dam to further assess spawning movement and the spawning population structure. Specifically, the objectives of this study were to:

1) Determine the downstream influence of Milltown Dam by measuring the distances largescale suckers migrate to reach the dam each spring.

2) Quantify the environmental cues that trigger these large migrations.

3) Determine non-spawning movements and habitat use of largescale suckers during high-water events.

4) Measure seasonal habitat use and home-range.

5) Measure diel movement and habitat use and compare summer and winter.

6) Determine population structure and size of spawning largescale sucker population at Milltown Dam.

7) Determine the timing of feeding movements into a small tributary.

Study Area

This study was completed along the Clark Fork River and its tributaries near Missoula, Montana. (Figure 2).

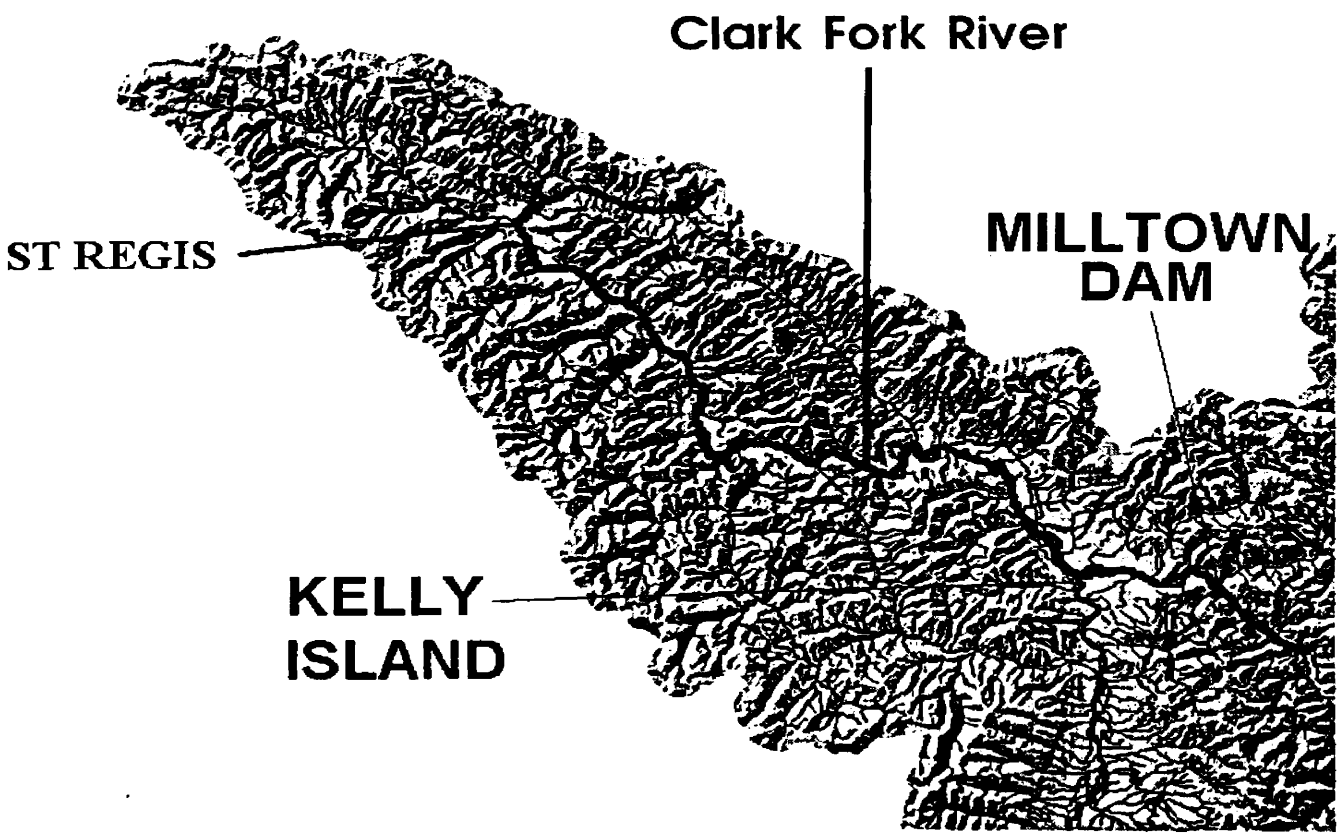


Figure 2.- Study area. Direction of river flow is from right to left.

The Clark Fork River at Missoula has a drainage area of 15,545 km^2 (USGS 1991), a mean annual flow of 84.245 m^3/sec and near Missoula flows primarily through Belt Series sediments as well as recent valley and terrace deposits. The upstream boundary of this study is the Milltown Dam, located at the confluence of the Blackfoot and Clark Fork Rivers. The dam was constructed in 1906-1907 and contains five 600-640 kilowatt capacity generators. Milltown Dam is a low-head, run-of-the river development with little storage capacity. The dam creates a heavily silted 300 acre-foot reservoir on its upstream end and has scoured a 25 meter deep pool on its downstream end (Mabbott, pers. comm.). No significant thermal stratification occurs in the reservoir (Hill et aL 1993) The dam is at the lower end of the longest Superfund site in the United States, and periodic heavy-metal releases from the reservoir are believed responsible for both chronic and acute declines in downstream fish populations (Berg, pers. comm.; Hill et al. 1993). Fish are unable to pass upstream of the dam (Hill et al. 1993); however, successful downstream passage through an open sluice has been observed in some species (Hill et al. 1993; Swanberg 1996). The downstream end for this study (furthest detected fish movement) was St. Regis, approximately 120 river km downstream of Milltown Dam. Tributaries included in the study are Rattlesnake Creek and the Bitterroot River.

The Clark Fork River near Missoula has native populations of largescale sucker, westslope cutthroat trout *Oncorhynchus clarki lewisi*, bull trout *Salvelinus confluentus*, sculpin *Cottus* sp., longnose sucker *Catostomus catostomus* , mountain whitefish *Prosopium williamsoni*, peamouth *Mylocheilus caurinus*, longnose dace *Rhinichthys cataractae* and redside shiner *Richardsonius balteatus*. It also contains introduced populations of white suckers *Catostomus commersoni*, northern pike *Esox lucius*, largemouth bass *Micropterus salmoides*, rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta*..

Rattlesnake Creek

Rattlesnake Creek is a third-order tributary to the Clark Fork River in Missoula, Montana (mean annual flow 100 CFS; drainage area 150 km^2; mainstem length 10 km). The creek enters the Clark Fork River seven km downstream from Milltown Dam. I surveyed a 150 m section of stream, 200 m upstream from the confluence with the Clark Fork River. The section of creek surveyed is highly channelized, consisting primarily of riffles with shallow pools that, during this study, were all less than 0.6 m deep. In fall, Rattlesnake Creek has populations of largescale sucker, mountain whitefish, sculpin, rainbow trout, bull trout, westslope cutthroat trout and brown trout.

Methods

Radio Telemetry

From May, 1996 to February, 1997, 38 largescale suckers were implanted with radio transmitters. In April and June of 1996 (during spawning), 16 largescale suckers (8 males, 6 females and 2 of unknown sex) were collected at Milltown Dam. Mean length = 478 mm (range 400-550 mm). In February 1997, 20 largescale suckers (11 males, 9 females) were captured 15 km downstream of Milltown Dam at Kelly Island. Mean length = 493 mm (range 394-565 mm).

Largescale suckers were either electrofished or captured with hook and line. Electrofished fish were captured from a jetboat or driftboat mounted with a Coffelt Model VVP-15 electrofisher with a DC output of 1,000 watts and 200-300 volts. The largescale suckers implanted with transmitters were individually anesthetized with tricane methanosulphate (MS 222; 150 mg/L) until equilibrium was lost. Fish were measured (total and fork length), weighed and placed ventral side up in a V-shaped Plexiglas trough. Surgeries followed the guidelines of the American Fisheries Society (Hart and Summerfelt 1975; Winter 1996). Gills were bathed with the MS-222 solution to maintain anesthesia during surgery.

A 3-4 cm incision was made just lateral to the linea alba approximately 3 cm anterior to the pelvic girdle. The incision penetrated the peritoneum but did not perforate the abdominal viscera. Each fish received one 5.1-16.3 gram Lotek transmitter (transmitting 150 MHz signals) with shielded whip antennas. Transmitters did not exceed 2% of the fish's body weight. Transmitters were implanted by placing a metal shield through the incision and guiding the shield along the abdominal wall posterior to the pelvic girdle. A hollow needle was inserted posterior to the pelvic girdle and guided through the abdominal cavity by the metal shield. The end of the whip antenna was threaded into the needle and both needle and antenna were withdrawn through the needle's point of insertion. The transmitter was placed in the abdominal cavity and was secured in position beneath the pelvic girdle by pulling gently on the antenna. Incisions were closed with 3-4 silk sutures (Ethicon 3/0). Surgeries lasted 6-12 minutes, after which fish were placed in pure water for 5-15 minutes until equilibrium was regained. Fish were released back into the river.

Immediately after release, fish were tracked daily for two weeks. Fish were tracked on foot using a three-element Yagi antenna and Lotek model SRX_400 telemetry receiver. Triangulation provided confirmed accuracy within 2-10 meters for fish within 50 meters of the observer (McEvoy, unpublished data). Accuracy increased as distance to the transmitter decreased and, for most observations, was within 3 meters. Fish were also frequently tracked from a bicycle with an omni-directional antenna mounted on the rear rack, from cars and from canoes. In addition, four flights were conducted during the two-year study. A 3-element Yagi was mounted on the wing of a Piper Super-cub flown 300-500 meters above the river. Accuracy of aerial relocations was estimated only within 100 m (Winter 1996).

After the initial two-week tracking period, fish were tracked 1-5 times per week during spring, winter and fall, depending on the fish's location and accessibility (largescale suckers near the University of Montana were tracked almost daily throughout the study). In winter, fish did not move long distances and river access was often limited; during this time, fish were tracked every 2-6 weeks. Because infections caused by incisions closed with sutures peak within 30 days after surgery (Swanberg et al, in press), no relocation data from the first 30 days post surgery was used in the movement analysis.

In addition to mobile tracking, two fixed-location stations, one at Milltown Dam and the other at the confluence of Rattlesnake Creek and the Clark Fork River, were established to monitor hourly fish movements. Both stations used three Yagi antennas directed to distinct portions of the river. Low gains at each of these antennas minimized overlap of detection between antennas. Receivers were plugged in to a continuous power source and left at these stations for 1-7 days. Water temperature was measured at Milltown Dam and Kelly Island each hour in 1997 with Stowaway ® data loggers.

Rattlesnake Creek, Tributary Use and Diet

As part of an ongoing study of Rattlesnake Creek, I measured movements of largescale suckers into the creek as mountain whitefish were spawning in 1996 and 1997. Bank and snorkel surveys of the lower section of the creek were conducted (see Study Area) throughout 1996 and 1997. Both mountain whitefish and largescale suckers were readily observed from the bank. With the observation of the first largescale suckers in the creek on September 17, 1996, I began a series of four single-pass electrofishing surveys (with Coffelt model VVP-15 backpack shocker) which concluded on November 21 (Figure 8). In 1997, similar single-pass surveys were conducted once every three weeks for 15 weeks.

During each survey, mountain whitefish were sexed, evaluated for reproductive status, measured (total length), fin clipped and released. Largescale suckers were similarly measured and tagged with colored anchor tags and caudal fin clips identifying capture dates. Gut samples were taken from the anterior guts of four largescale suckers captured in Rattlesnake Creek during the October 31, 1996 survey. In addition, gut contents of 30 largescale suckers captured in the Clark Fork River at the end of October 1996 were combined into one sample.

Diel Movements

To evaluate diel movement and habitat use of largescale suckers in summer and winter, I tracked 7 largescale suckers hourly for 24 hours on 14 separate occasions (11 summer and 3 winter periods). Fish were selected by their accessibility and by the presence of public land on which to stay for 24 hour periods. Three fish were tracked at the confluence of Rattlesnake Creek and the Clark Fork River (7.5 km downstream of Milltown Dam). Four fish in the Kelly Island vicinity, 17 km downstream of Milltown Dam, were tracked. Following the methods described by Young et al. (1997), posts with orange flagging (for night visibility) were placed at 50 m intervals along the river where tagged fish were located. Each hour, all fish in one region were located and their positions were marked along the bank and measured against the permanent marks. Distance of the fish from the bank was recorded. Habitat parameters were measured the day following tracking in order to avoid altering fish behavior during 24 hour studies Transects were established at 40 m intervals from the upstream extent of one riffle to the upstream extent of the next riffle, including the pool in which the largescale sucker was found. At 4 m intervals along each transect, the following parameters were measured: depth (m) where the fish was located, velocity (cm/s) 10 cm above the substrate, substrate type and overhead cover. Water velocity was measured 6 cm above the substrate. Velocity was measured using a Marsh-McBirney® model 2000 flow-meter. For analysis, data from both locations were pooled.

Spawning Population

In the spring of 1996, 1997 and 1998, largescale suckers were repeatedly collected at Milltown Dam. Largescale suckers were captured either from jetboat as described above or by collecting fish that swam to the face of the dam and entered a confined pool fed by the radial gate. In 1996 and 1997, 1400 largescale suckers were captured. After capture, fish were anesthetized, weighed (g), measured (FL and TL), checked for reproductive status and marked with Floy® T-bar tags. Tags were placed on the fish's left side 2-3 cm below the dorsal fin. Attempts were made to place the T-bar between the neural spines following guidelines of the American Fisheries Society (Guy et al., 1996). Recaptures of these fish were used for age and growth estimates. In 1998, a repeated mark and recapture sample was taken at the radial gate of Milltown Dam, from which a population estimate of spawning fish at the dam was made. The radial gate was opened to accommodate a flow which permitted entry of fish. This was done three times each week beginning on March 14, 1998 and concluding on April 24, 1998, when high flows through the dam prevented further use of the radial gate as a trap. Largescale suckers were captured in the pool by backpack electrofisher or with dip nets. All fish were sexed, fin-punched according to date of capture, observed for previous marks, and released into the Clark Fork.

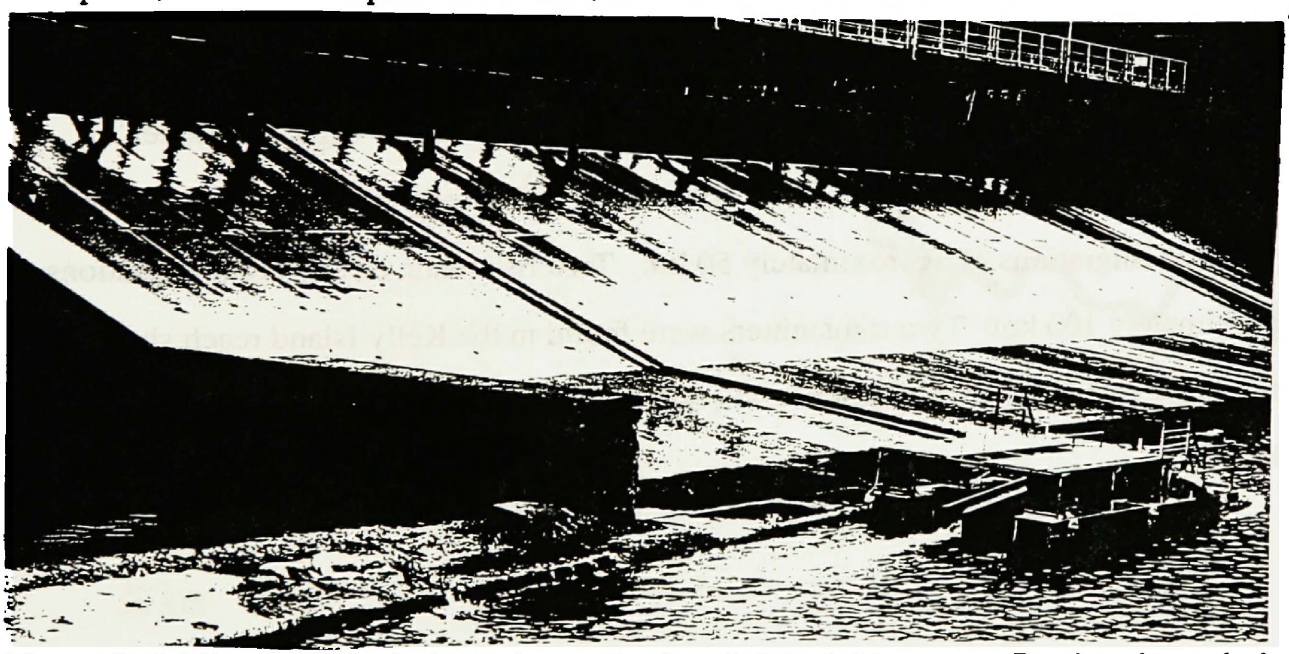


Figure 3. Milltown Dam during winter. Pool on left is fed by water flowing through the radial gate. During higher flows, no drop-off exists from pool into river water. Apron of dam is on right. Fish trap (not used in this study) is secured to apron. Power generating plant (not shown) is left of radial gate pool.

Results

Downstream Migrations from Milltown Dam

Downstream migrations of largescale suckers captured at Milltown Dam during the Spring of 1996 and implanted with radio transmitters were continuous. Fish that stopped downstream migrations for greater than 24 hours did not move from that area again that season. Downstream migrations from Milltown Dam lasted two to three weeks. Migration distances were highly variable (figure 4). The average downstream movement was 26.3 km (range 0-111 km). Four fish did not move out of the capture area and remained in the deep downstream pool at Milltown Dam throughout the life of their transmitters. This pool is 25 m deep, which is well beyond the maximum transmission depth of 5-15 meters. These fish were relocated very infrequently. Eight of sixteen largescale suckers moved 14 -17 km from Milltown Dam to Kelly Island. Two largescale suckers made migrations of approximately 50 km. Two fish made downstream migrations of approximately 100 km. Two transmitters were found in the Kelly Island reach shortly after fish were released. It is not known whether these fish died or if the transmitters were expelled.

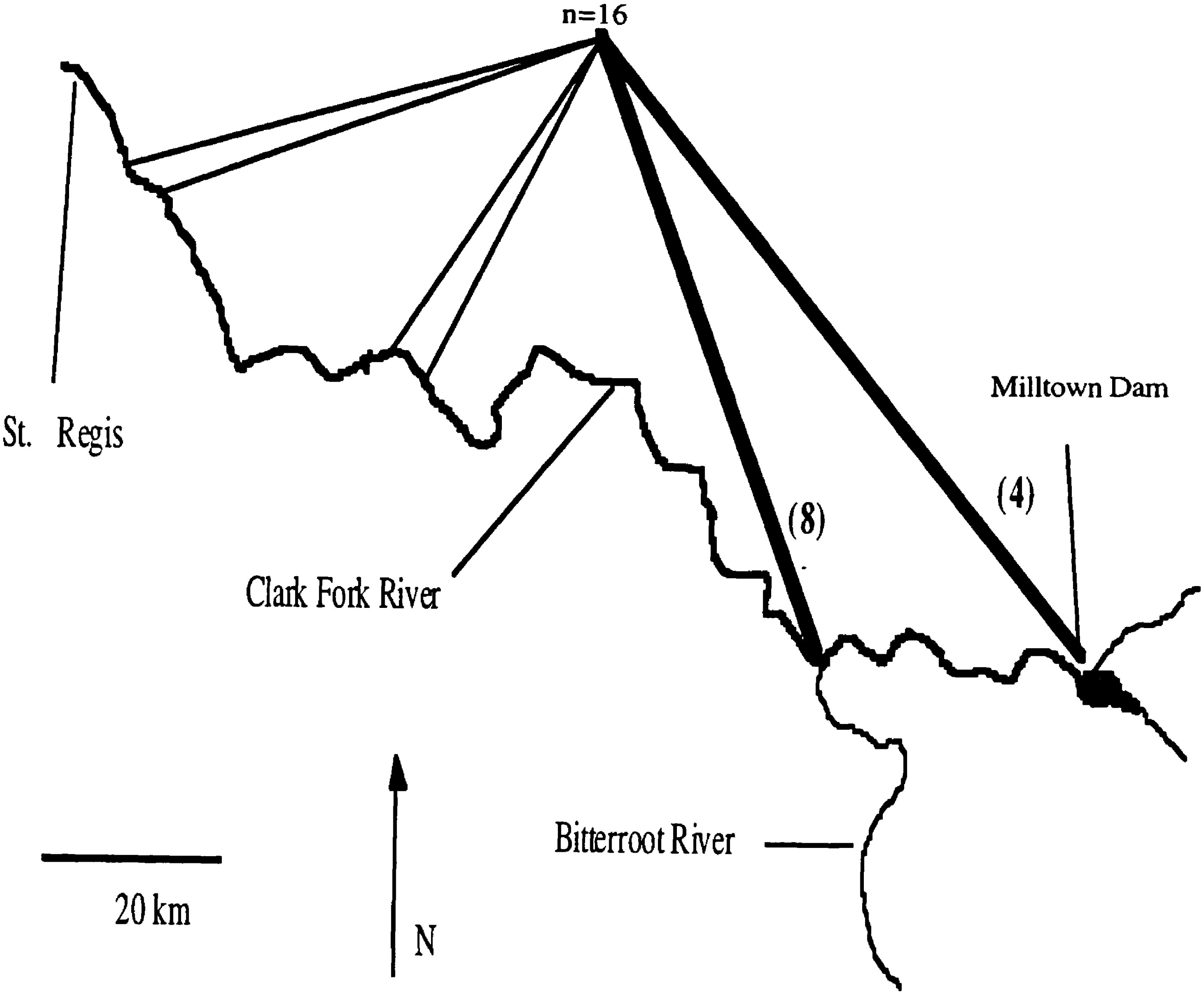


Figure 4. - Maximum downstream migrations of 16 largescale suckers with radio transmitters captured during Spring spawn at Milltown Dam, 1996. Numbers in parentheses indicate numbers of fish found in that location. River flow is from right to left.

Home Range and Habitat Use

To quantify home range, ten largescale suckers with transmitters were tracked one-to-three times each week from July 1997 to February, 1998. Home range was defined as the maximum linear upstream and downstream distance traveled other than during spawning migrations (Matheney and Rabeni 1996). Nine of ten largescale suckers remained within one pool-riffle sequence during this period, although daily movements during summer and fall were greater than during winter (see Diel Activity, this report).

Fig. 6 depicts a typical home range for one fish with a transmitter that was restricted to one pool-riffle sequence. This particular fish did not migrate to Milltown Dam during the spring. During summer and fall, this fish moved between a 2.5 m deep pool during daylight and 0.2 m riffle at night (see Diel Activity). From May 20 to June 9, 1997, at the peak of the hydrograph, this fish moved into a flooded cottonwood stand with zero water velocities during the day. At night, this fish moved along the bank 150 meters into the lower sections of Rattlesnake Creek. It remained in lower Rattlesnake Creek, again on the downstream side of flooded vegetation, throughout the night, and returned to the cottonwood stand the following morning. This pattern continued throughout May and June, and was detected by the permanent station at Rattlesnake Creek (Figure 5). There were two other largescale suckers with transmitters at the Rattlesnake confluence, and both made similar but less frequent nightly movements into the creek.

Fig. 7 depicts movements of a largescale sucker with a larger home range (5.35 km) than the nine other largescale suckers with radio transmitters. This fish moved extensively through the summer and fall. This fish was captured at Kelly Island in February, 1997. From May until July it migrated to Milltown Dam (see "Spawning Migrations" below) and in July returned to Kelly Island. During this time, the nine other largescale suckers whose home-range was measured were moving only within 200-300 m areas. After returning from its spawning migration, this fish was tracked near the downstream base of a newly enlargēd irrigation weir that prevents upstream fish movement (Figure 5). In July and August, this fish circled Kelly Island. Movements occurred at dusk and dawn. In September, this fish completed its movements into a newly formed pool that was created upstream of the weir.

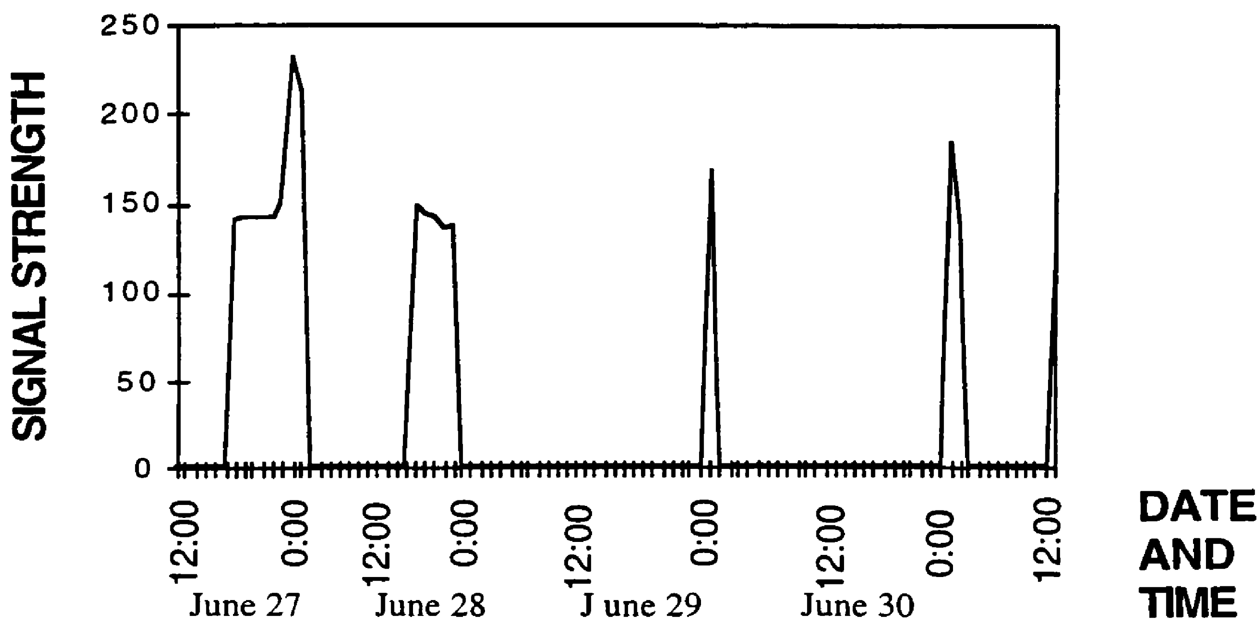


Figure 5.- Nightly movement of one largescale sucker into Rattlesnake Creek on four successive nights. Positive readings on the Y-axis indicate detection of the fish 25 m upstream of the confluence with the Clark Fork River. This fish was tracked each day to confirm its return to the Clark Fork River during daylight.

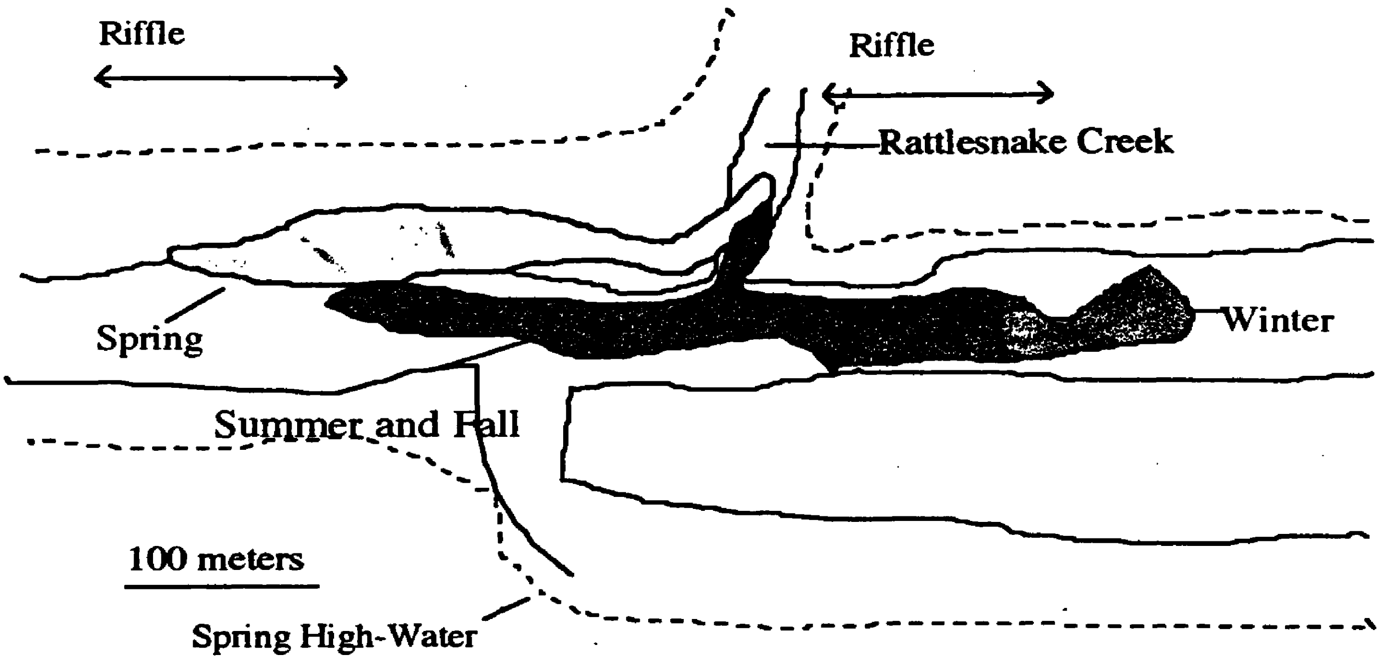


Figure 6.- Home range and seasonal movements of one largescale sucker from October, 1996 until October, 1997. This fish was located 290 of 365 days.

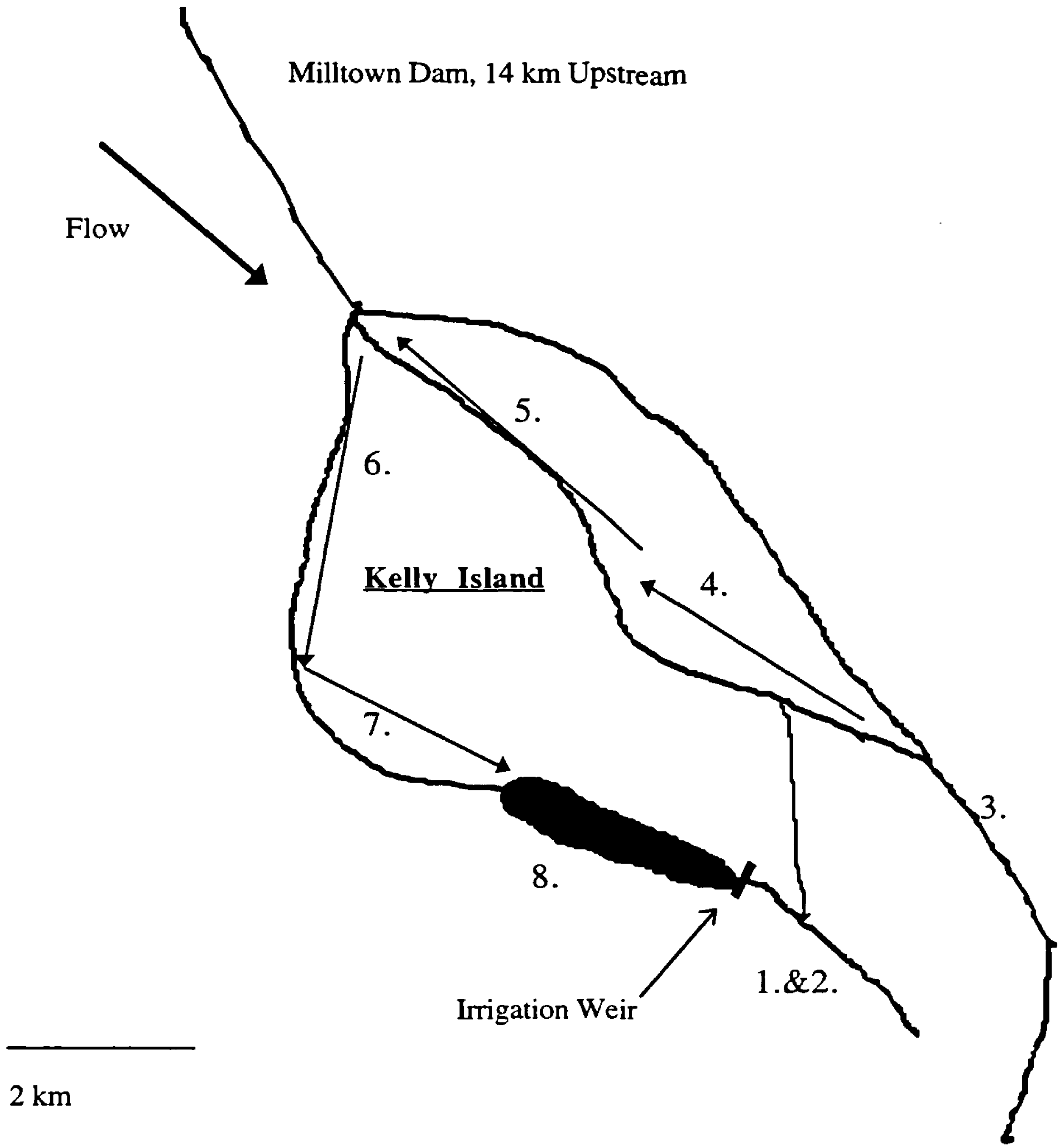


Figure 7- Movement of largescale sucker around irrigation weir. 1: Capture Location February, 1997. 2: Migrates to Milltown Dam May, 1997. 3: Returns to Kelly Island July, 1997. 4-7: Movement Around Kelly Island July - August, 1997. 8: Moves into deep pool upstream of irrigation weir September, 1997. Remains throughout winter.

Spawning Migrations and Movement at Milltown Dam

In the Spring of 1997, 26 active transmitters remained in largescale suckers (6 from 1996, 20 from 1997). Six of these largescale suckers (two from 1996, four from 1997) made migrations to Milltown Dam in 1997. One of these fish was located only two times during this migration; data from its migration is not included in the results. All fish with transmitters that migrated to Milltown Dam began their migrations at Kelly Island.

In 1996, 1997, and 1998, largescale suckers began climbing the apron of Milltown Dam on March 13, 19, and 23, respectively (Figure 8). Maximum water temperatures for these days in 1997 and 1998 were 5 and 6.5 C. Temperature loggers were lost in 1996 high-flows. Similarly, the first largescale sucker with a radio transmitter began moving to the dam on March 22, 1997 (Figure 9). The four other largescale suckers with transmitters began migrations in April, June and August of 1997. Migrations of the six fish with transmitters (all originating in the Kelly Island complex) averaged 14 km. Mean distance per day was .78 km (range 0 -5.2 km). Migrations averaged 18 days (range 7-35 days). Largescale suckers with transmitters migrated both day and night .

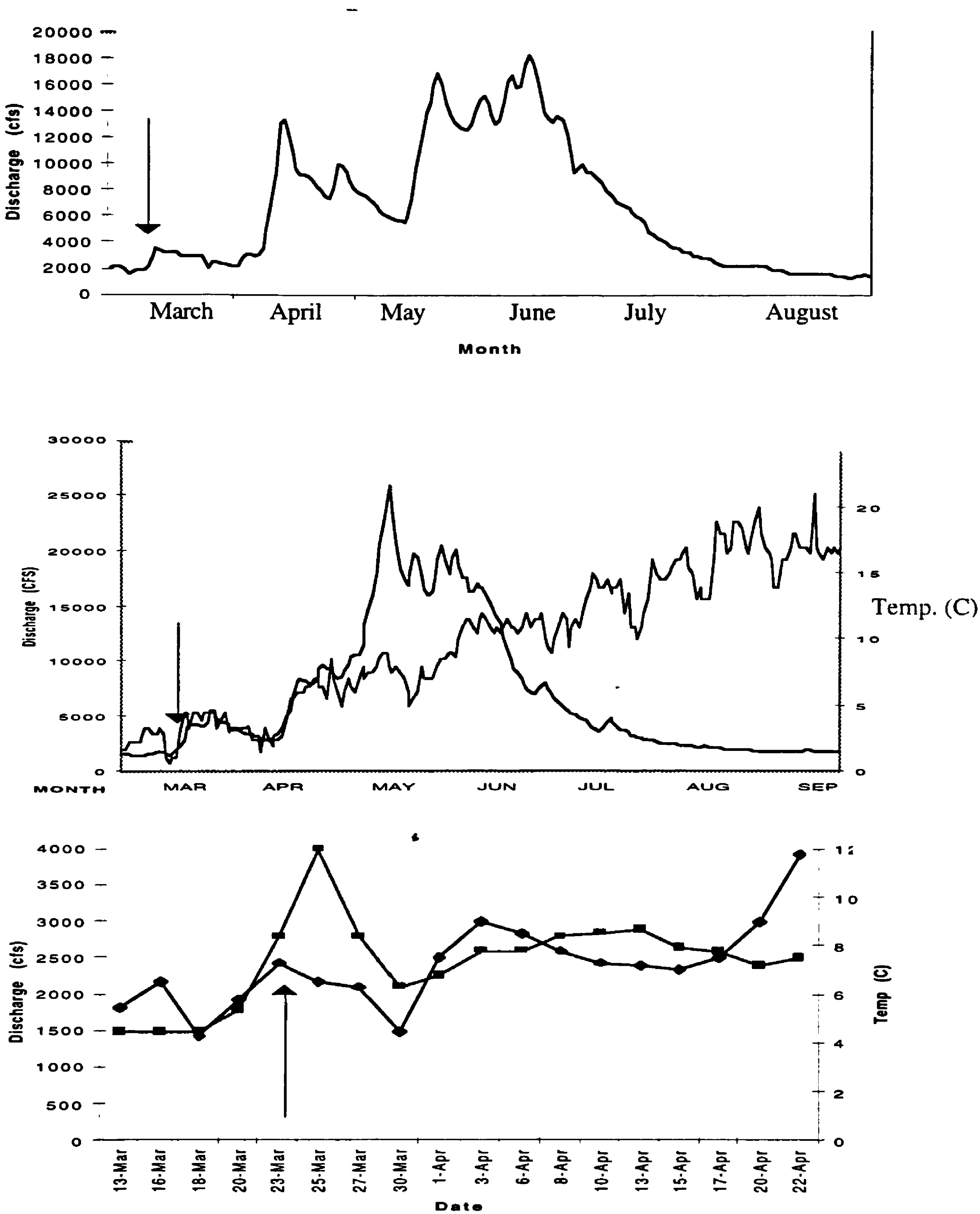


Figure 8. - Hydrograph for 1996 (top), and hydrothermographs for 1997 (middle) and 1998 (bottom) at Milltown Dam. Arrows indicate first observations of largescale suckers climbing Milltown Dam apron.

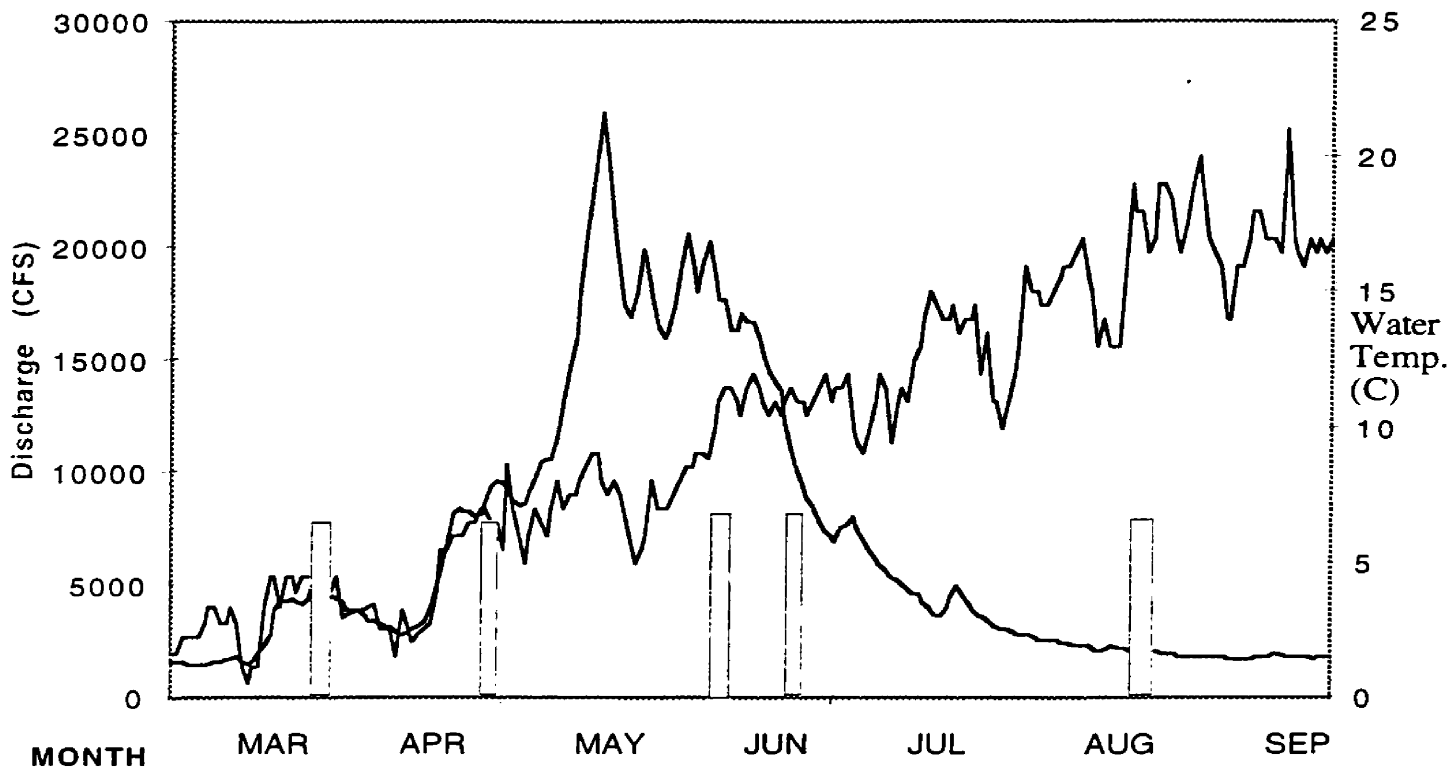


Figure 9.- 1997 hydrothermograph and onset of largescale sucker migrations. Yellow bars indicate days on which individual largescale suckers with radio transmitters began migrations to Milltown Dam

Migration durations corresponded with onset of migrations: largescale suckers with radio transmitters that began migrating earliest migrated at the slowest rate (figure 10). No fish were tracked migrating at the peak of the hydrograph (June 15-July 15). The two largescale suckers that began migrations before June 15 both moved into a flooded cottonwood stand with zero velocities for three and five days, respectively. During this time, a third largescale sucker (that did not migrate to Milltown) moved into this same stand and remained there for two weeks.

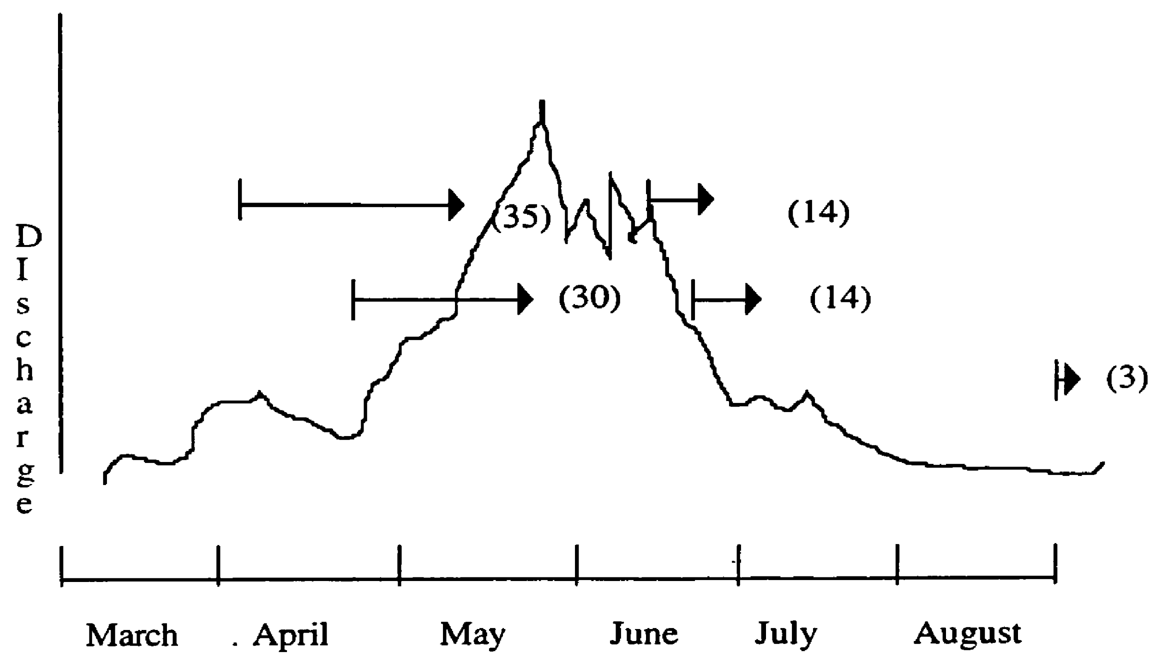


Figure 10.-Duration of migrations for five largescale suckers with radio transmitters. Vertical lines indicate onset of migrations. Arrows indicate arrival at Milltown dam. Numbers indicate days traveled. Red line indicates river discharge. All migrations are 15-18 km.

For largescale suckers with radio transmitters, duration of stay at Milltown Dam corresponded with date of arrival: fish that arrived at the dam earliest remained at the dam for the longest period of time (figure 11). Average residence at Milltown Dam was 26.6 days (range 5-55 days). The first largescale sucker that arrived at Milltown Dam, on April

27, remained at the dam for 55 days. The final two fish that migrated to Milltown Dam remained there for only five days each. From June 15 until July 15, four of the five largescale suckers that had migrated to Milltown Dam were present at the dam.

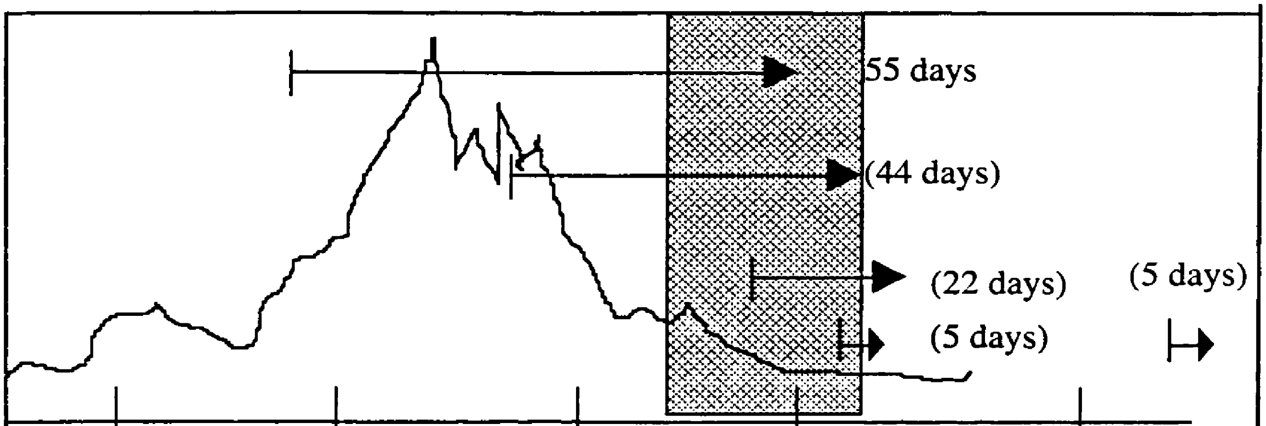


Figure 11.-Arrival (indicated by vertical lines) and departure (indicated by arrows) of individual largescale suckers at Milltown Dam. Blue hatched area represents four week period when four of five largescale suckers with radio transmitters are all at Milltown Dam. Red line indicates river discharge.

Spawning Habitat

Once at Milltown Dam, largescale suckers were tracked throughout the downstream pool but were primarily found along a flooded willow island approximately 50 m downstream from the dam. Access to the island was not possible during high-flow but substrate was later found to be coarse cobble (20-25 cm) with a significant amount of coarse woody debris caught in the willows. Ripe male and female largescale suckers were electrofished on this island in April 1997, before high-flows. Fisheries biologists at MT

Fish, Wildlife and Parks consider this island to be a spawning area for rainbow trout that migrate to Milltown Dam and are similarly unable to pass upstream (Berg pers. comm.).

Eggs and Emergence of Young of the Year

On June 17, 1997, largescale sucker eggs were found in small (1-3 cm) gravel in Union Creek on the Blackfoot River. Eggs were found within 20 meters of the outlet into the Blackfoot River.

On June 23, 1997, the first largescale sucker larvae were collected in the Clark Fork River. These fish were stage 1 prolarvae (Auer 1982) with small yolk sacs on their ventral surfaces. Lengths were 11-12 mm. Habitat was a backwater pool at the confluence of the Clark Fork and Bitterroot Rivers.

Return Migrations

From July until August, 1997, the five largescale suckers with radio transmitters that made identifiable migrations to Milltown Dam returned from these migrations. All five fish returned to within 200 meters (range 0-200) of their locations before migrations began. Four of the five fish returned to the same pools they inhabited before migrating. One largescale sucker returned to a pool 200 meters upstream of its previous location.

High-Flow Movements

Of the 20 largescale suckers that were implanted with transmitters in February and March, 1997, three distinct movement patterns were discernible during peak discharges (April - August) (Figure 12). Five of the largescale suckers migrated to Milltown Dam. Seven largescale suckers moved downstream 10-15 km and, when accurately located, were found in flooded side-channels. Eight largescale suckers remained within Kelly Island and, again when accurately located, were found in flooded riparian areas with low velocities and in flooded side channels.

During peak discharge (27,000 cfs) in 1997 (May 15 - June 10), six largescale suckers that did not migrate to Milltown Dam were found in low-velocity side channels and flooded riparian stands (figure 13). Tracking was extremely difficult during this time of the year due to limited access to many of the interior river channels. However, all fish that could be located accurately remained in low velocity side channels throughout the peak of the hydrograph.

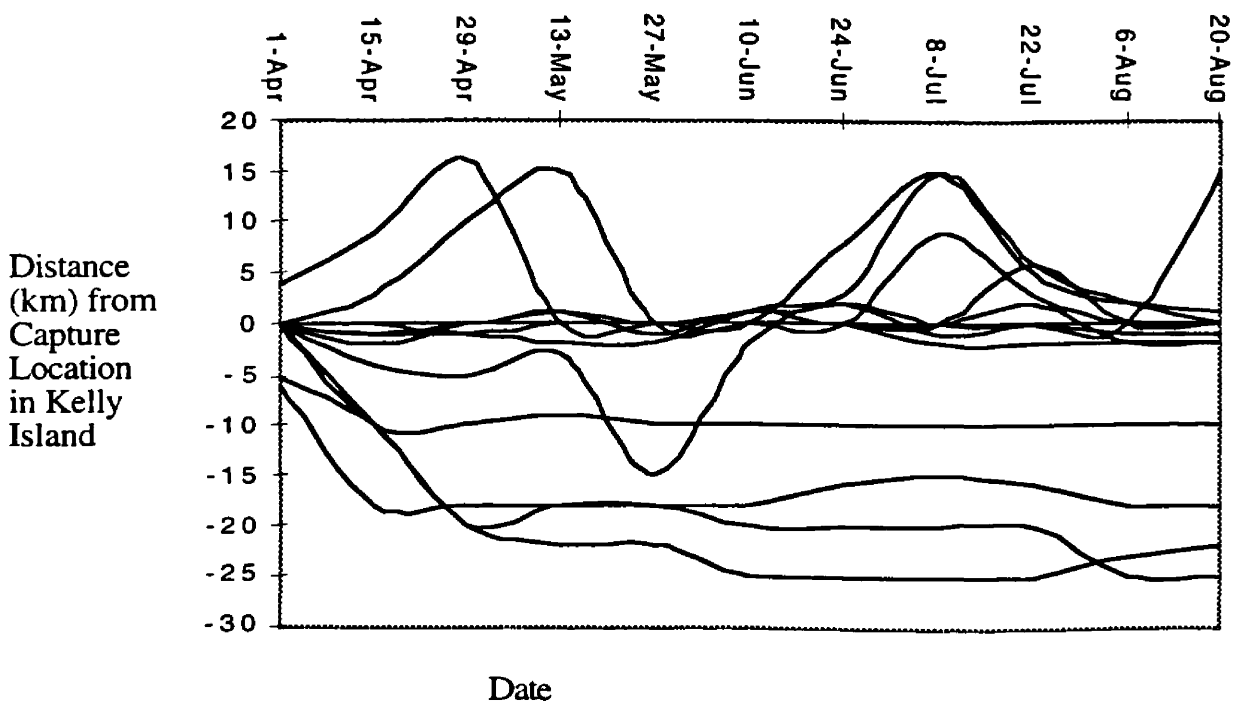


Figure 12.- Movements of 20 largescale suckers with transmitters from April 1997-August, 1997. Y-axis values are distances are upstream (positive) and downstream (negative) from location of capture on Kelly Island.

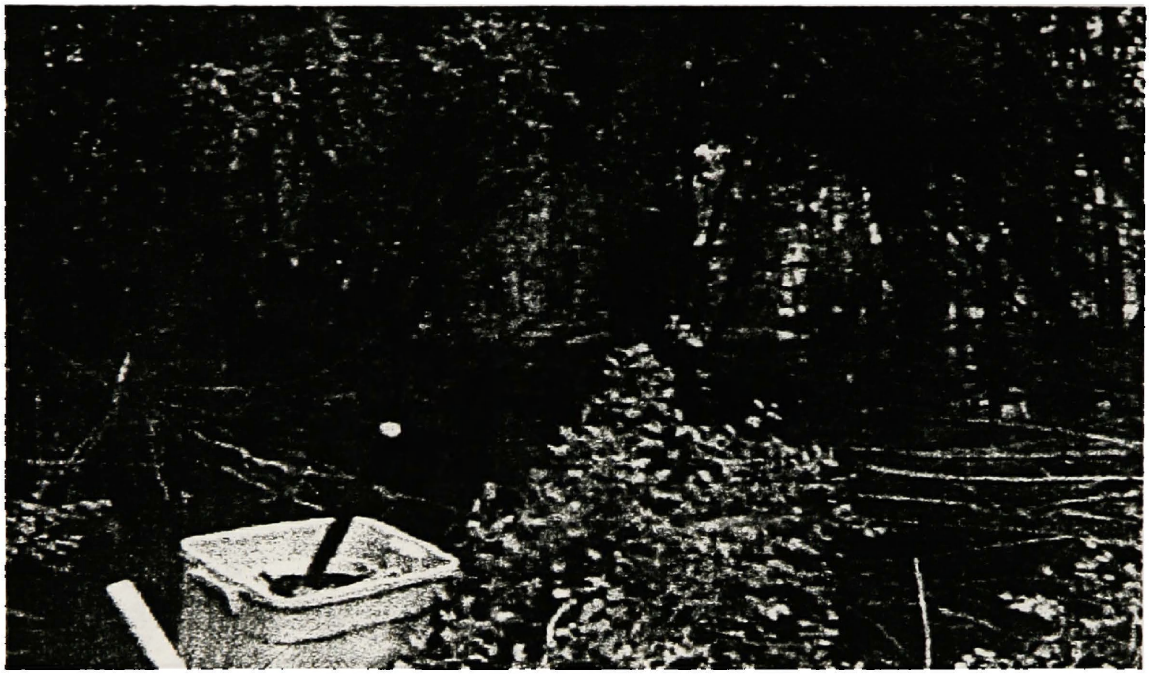


Figure 13. Flooded riparian area at Kelly Island. One largescale sucker was tracked into pool behind tub for two weeks at peak of the hydrograph.

To determine whether fish moving into these flooded did so to avoid high-flows or to spawn, I tracked largescale suckers into accessible flooded riparian areas and sampled for evidence of spawning. Areas were shocked with backpack shocker and seined for larvae and floating eggs. Substrate was sampled in each site and examined for the presence of eggs. I found no evidence of spawning in any of these areas.

Movement into the Bitterroot River.

Only two of the 36 largescale suckers with transmitters moved into the Bitterroot River. One largescale sucker moved from its location of capture in Kelly Island 20 km upstream into the Bitterroot. This movement occurred in June, 1997, when three other largescale suckers with transmitters were making spawning migrations to Milltown Dam. One other largescale sucker moved from its capture location in Kelly Island 100 m upstream of the confluence of the two rivers and remained there for six months (the remainder of its transmitter life).

Annual And Non-Annual Migrations

Two of sixteen largescale suckers implanted with radio transmitters in 1996 returned to Milltown in 1997. Twelve of the 953 largescale suckers that were floy-tagged at Milltown Dam in 1996 were recaptured at the dam in 1997. Six of the 1996 fish were captured in 1998. In 1998, two of 333 fish tagged in 1997 were recaptured. There is no significant difference in 1998 recapture rates between the fish marked in 1996 and those marked in 1997 ($\chi^2 = 0$, $p<.0001$).

Rattlesnake Creek

In 1996, largescale suckers were first observed from the bank in Rattlesnake Creek on September 8; no mountain whitefish were seen at this time. I began electrofishing surveys the following week. During electroshock surveys on September 17 and October 31, mountain whitefish were present, but largescale suckers were more abundant in the creek (Figure 14). Numbers of largescale suckers rose slightly ahead of mountain whitefish densities, peaking on October 31, approximately one week before mountain whitefish reached their peak densities on November 8. Similarly, largescale sucker densities decreased before those of mountain whitefish; only two largescale suckers were captured with 52 mountain whitefish on November 21. Throughout the survey, most mountain whitefish were ripe males (265 of 288 mountain whitefish captured on November 8). The remaining mountain whitefish were ripe females (10 out of 288 on November 8).

In 1997, largescale suckers were again observed feeding on mountain whitefish eggs. However, unlike 1996, in 1997 largescale suckers moved into Rattlesnake Creek throughout much of the summer and early fall. The first electrofishing survey on September 17, 1997, captured 15 largescale suckers, four weeks before the first mountain whitefish arrived (Figure 15). By October 31, largescale sucker numbers in the study section increased to 22, with 45 mountain whitefish. At the peak of the mountain whitefish spawn, on November 8, 283 mountain whitefish were captured with 19 largescale suckers. On November 21, no largescale suckers and 75 mountain whitefish were captured. By December 1, visual observations from the bank found no mountain whitefish or largescale sucker in Rattlesnake Creek.

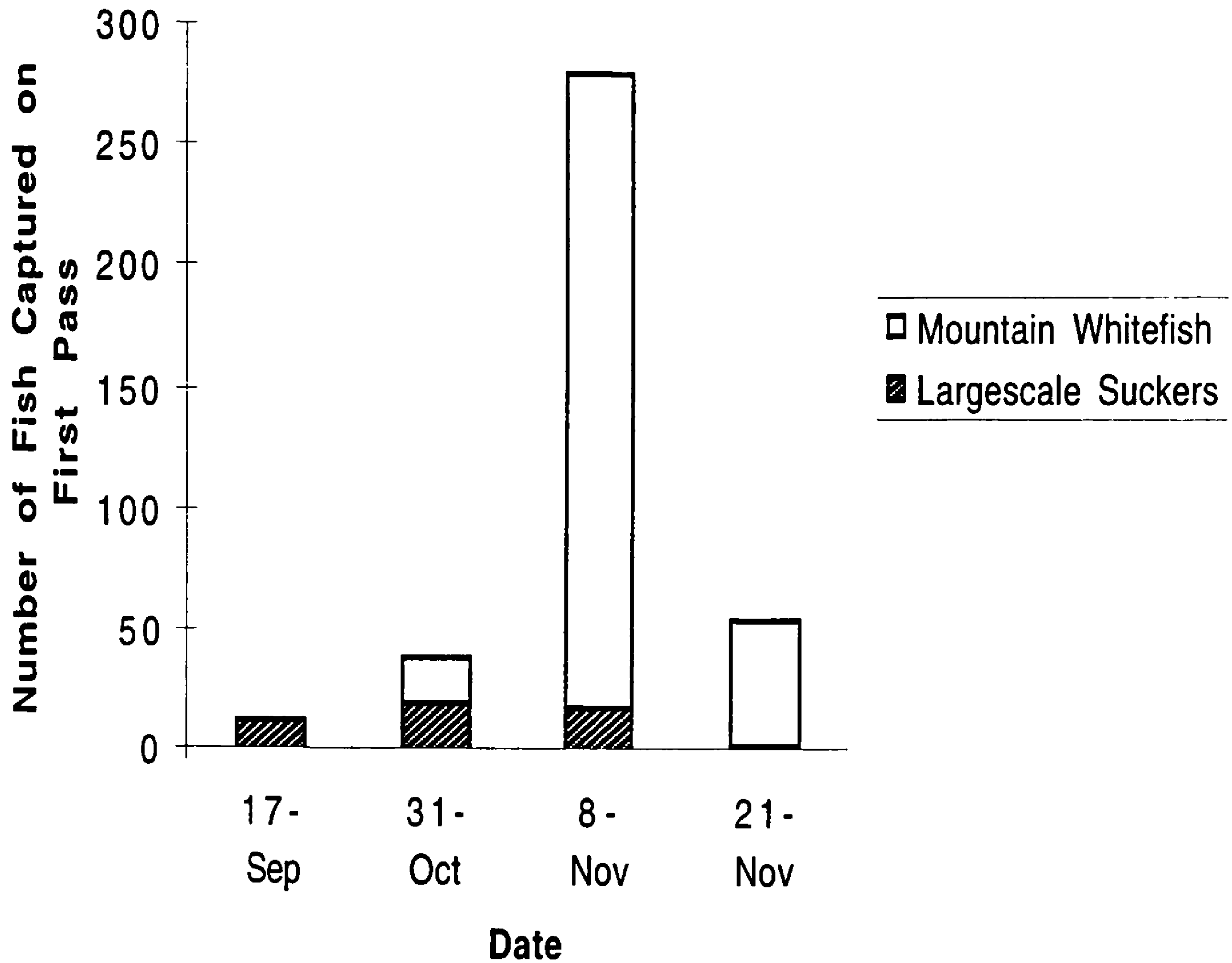


Figure 14. Number of mountain whitefish and largescale suckers captured on first electrofishing pass in Rattlesnake Creek, 1996.

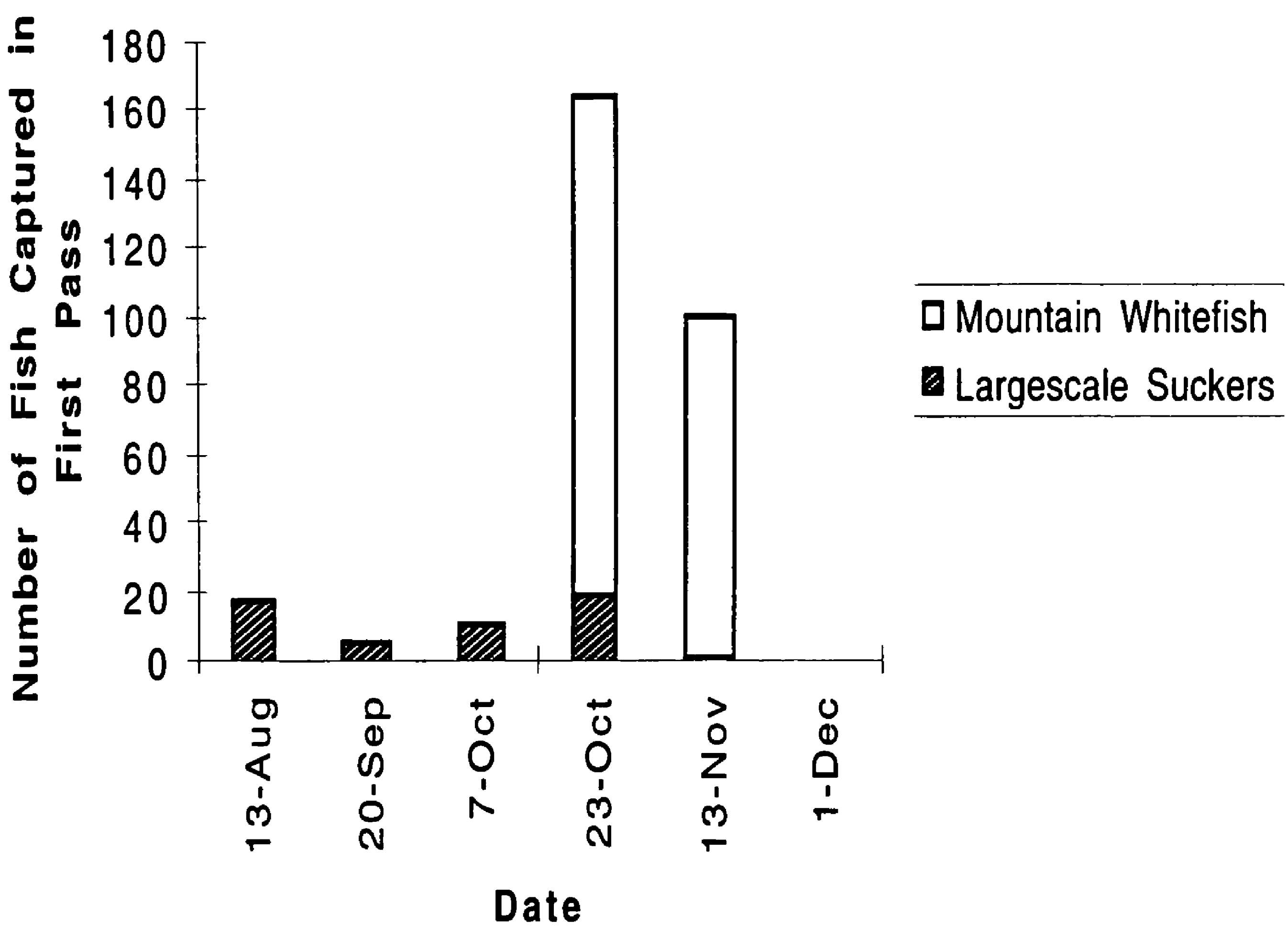


Figure 15.- Number of mountain whitefish and largescale suckers captured on first electrofishing pass in Rattlesnake Creek, 1997.

In 1996, recapture of marked fish indicated that, compared with individual mountain whitefish, the largescale suckers that moved into Rattlesnake Creek tended to reside in the study area for a majority of the whitefish spawn. Many of the largescale suckers remained in Rattlesnake Creek in excess of eight weeks. Four of 15 largescale suckers captured on November 8 had been tagged during the September 17 survey. Six of the remaining 12 fish had been tagged on October 31. In contrast, only 5 of the mountain whitefish captured during their peak density on November 8 had been tagged previously. I observed no largescale suckers in a 1 km section upstream of the study section, indicating that fish that were no longer observed in the study section were not moving upstream.

Gut contents of the four largescale suckers sampled in Rattlesnake Creek were composed entirely of mountain whitefish eggs. By comparison, gut samples taken from 30 largescale suckers randomly selected in the Clark Fork River during the same period and at the same time of day contained no eggs but instead consisted only of aquatic invertebrates (trichoptera, ephemeroptera, and plecoptera spp.), sand and algae (Figure 16).

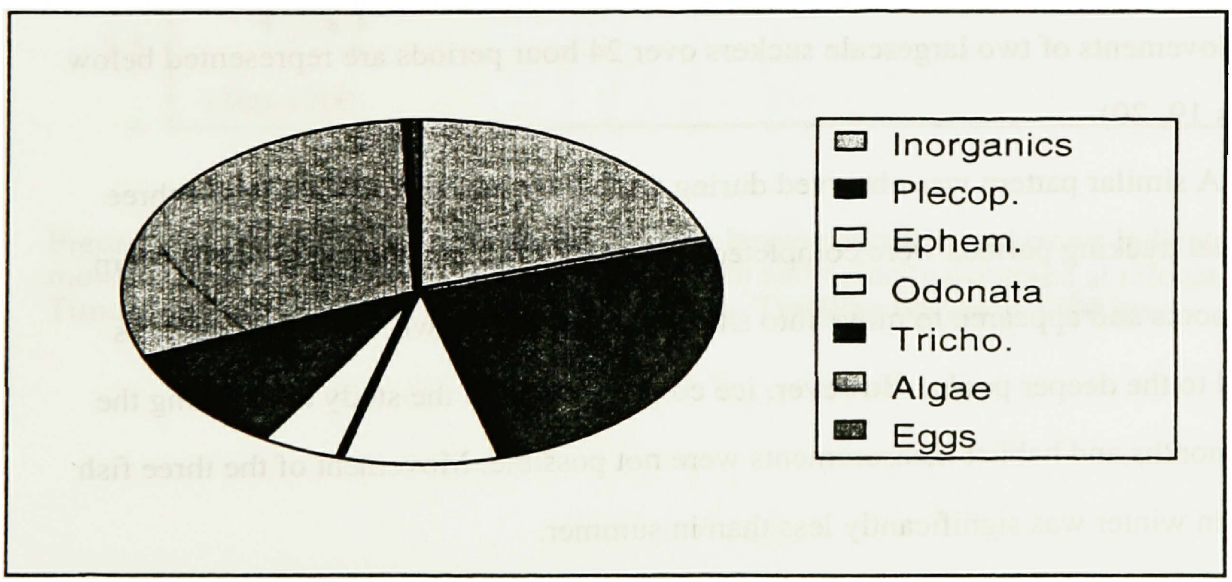


Figure 16.-Gut contents, by volume, of 30 largescale suckers collected from the Clark Fork River in October, 1996. Contents from 30 fish were combined in the measurements of volume.

Diel Movements

Largescale suckers tracked during summer (n=11) and fall months remained during daylight hours in deep pools with mean velocities of 10 cm/s (range 5 to 18) and a mean depth of 2.8 m (range 1 to 3.5) (Figure 17). Net movement was limited during daylight; mean net movement was three meters, which was the lower limit of accurate detection from shore. Fish were often found near large boulder and concrete blocks and were observed actively feeding on the substrate during the day. At dusk, fish moved rapidly (mean 50 m/hr) from pools into shallow (mean=35 cm) fast (mean = 100 cm/s) riffles (Figure 18).

Largescale suckers with transmitters remained in the riffles throughout the night, and no fish was observed moving more than 3 meters during night hours. At dawn, all fish moved from riffles back into deep pools, typically to the same area of the previous day. Movements of two largescale suckers over 24 hour periods are represented below (figures 19, 20).

A similar pattern was observed during the winter months, although only three individual tracking periods were completed. At dusk, largescale suckers moved from deeper pools and appeared to move into shallow riffles. At dawn, largescale suckers returned to the deeper pools. However, ice covered much of the study area during the winter months and habitat measurements were not possible. Movement of the three fish tracked in winter was significantly less than in summer.

These summer findings on individual fish were corroborated for larger numbers of fish by four snorkeling surveys done at night in Kelly Island. Although nighttime visibility was limited to 2 or 3 meters, no largescale suckers were observed in the deep pools in which they were observed earlier in the day. Instead, all largescale suckers found were in

20-30 cm deep water, throughout the width of the riffle. Snorkelers were unable to remain in these faster water areas to observe behavior. Fish were not visible from land.

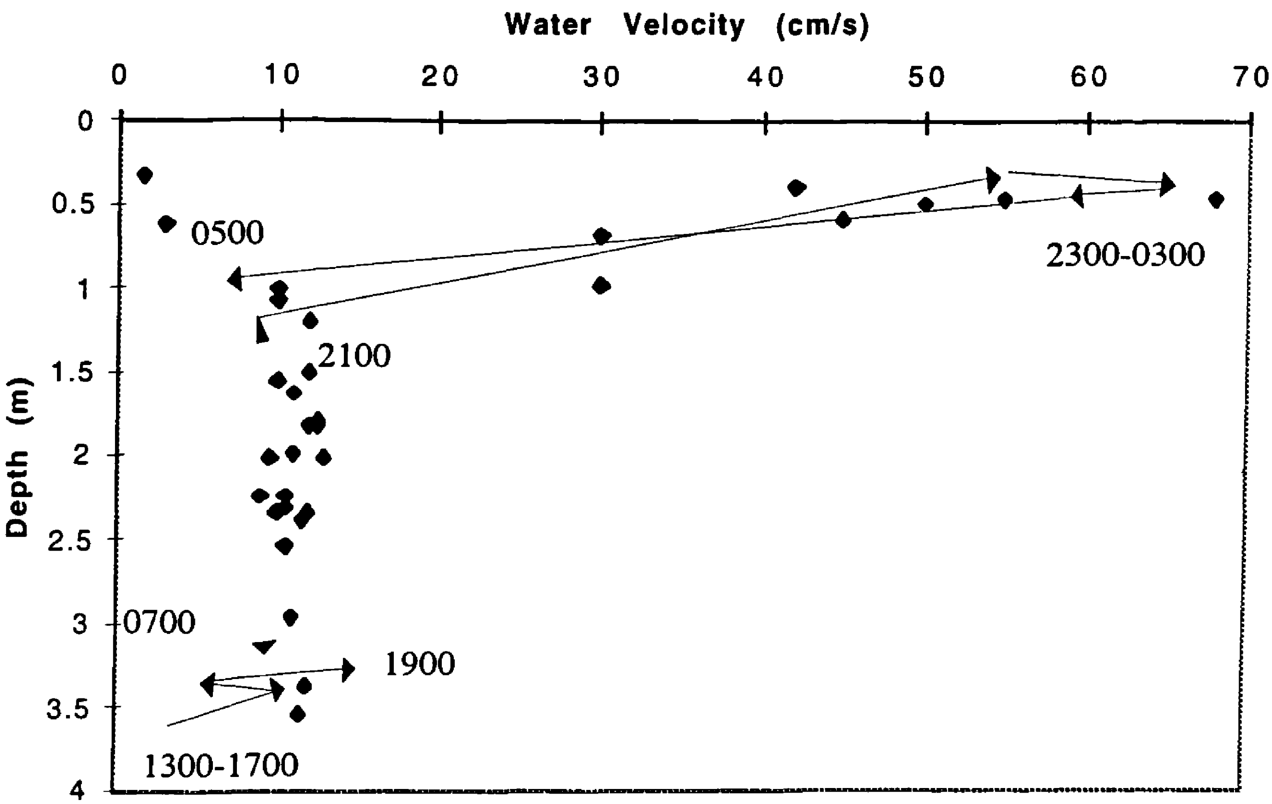


Figure 17. - Available and used habitat for one largescale sucker. Arrows indicate movements every two hours. "◊" indicates depth and velocity occupied at relocation. Time at each relocation is indicated in 2400 hrs. Tracking begins at 1300 hrs.

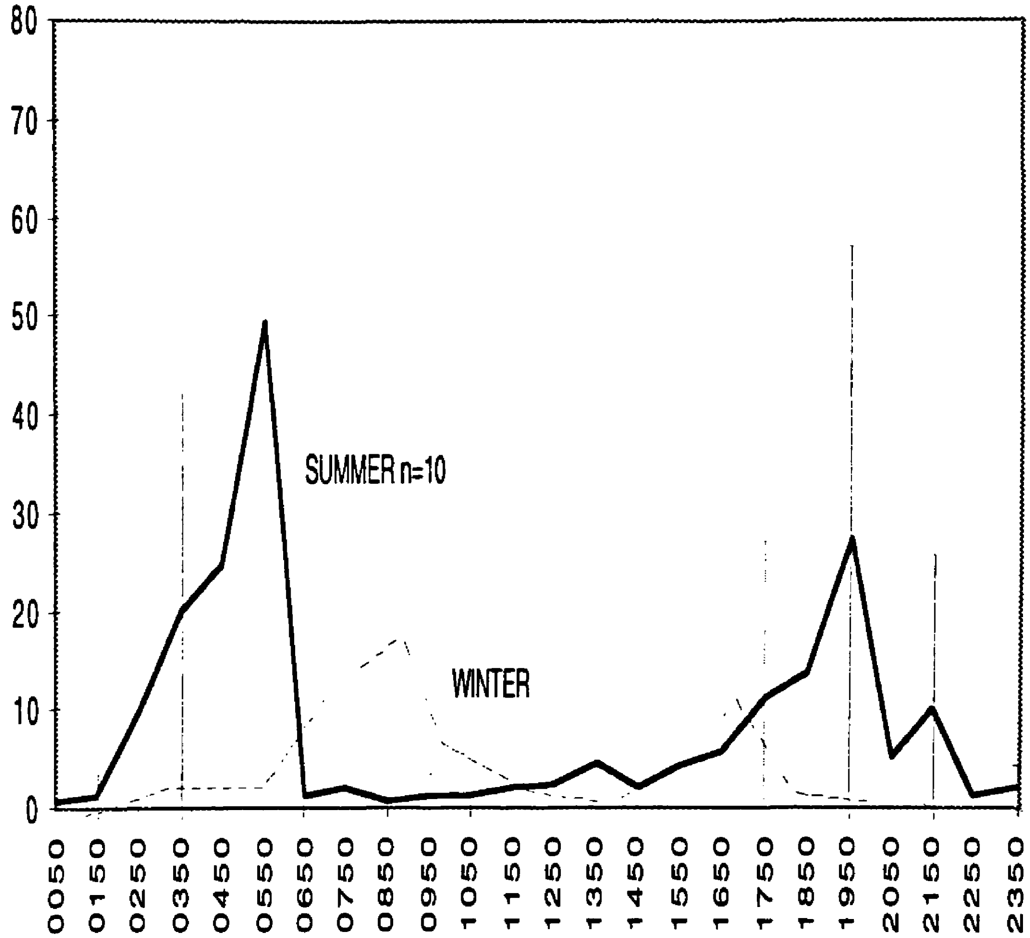


Figure 18.- Summer and winter hourly movements. Y-axis represents meters moved per hour, averaged over all fish for that season. X axis represents hour of the day. Error bars are one standard deviation, averaged over all fish for that hour and season.

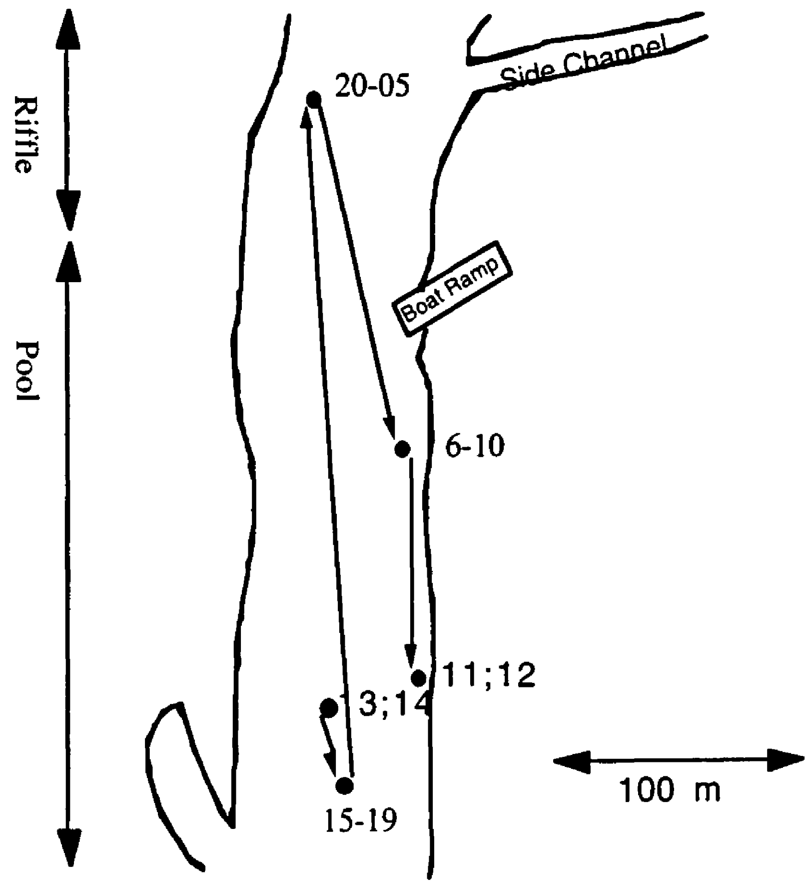


Figure 19.- Diel movements of one fish at Kelly Island over one 24-hour period June 26-27, 1998. Numbers indicate times of fish locations. Stippled circles represent fish locations at these times. Direction of flow is from top to bottom.

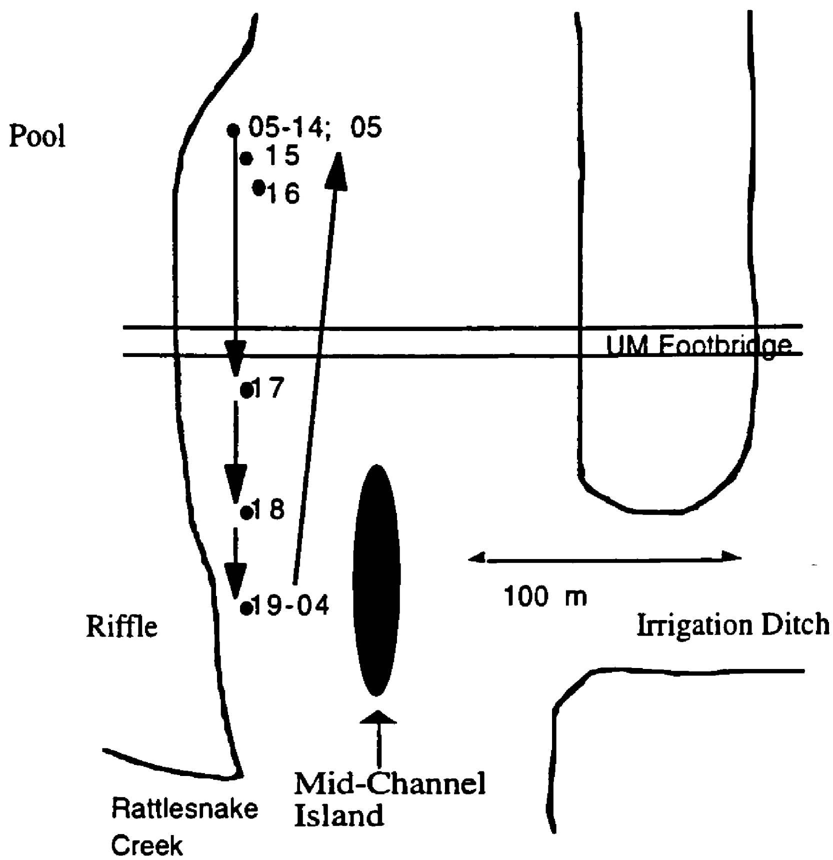


Figure 20. Diel movements of one fish near Rattlesnake Creek during one 24-hour period July 14-15, 1998. Numbers indicate times of fish locations. Stippled circles represent fish locations at these times. Direction of flow is from top to bottom.

Spawning Population

Population Size

From March 13, 1997, until April 24, 1997, 19 mark and recapture samples were taken of fish entering the radial gate pool at Milltown Dam. During this time, 4,518 largescale suckers were marked, of which 196 were recaptured. A Schnabel multiple-census estimate of largescale suckers entering the radial gate pool at Milltown Dam in 1998 was 41,443 (36,353 to 48,189) fish.

Size and Age at Maturity

Male largescale suckers matured earlier than females. The earliest males matured at 375 mm (age 5) Mean age at reproduction for males was 446 mm (age 6). The earliest female largescale suckers matured at 422 mm (age 6), with mean age at reproduction 496 mm (age 7-8) (Figures 21, 22).

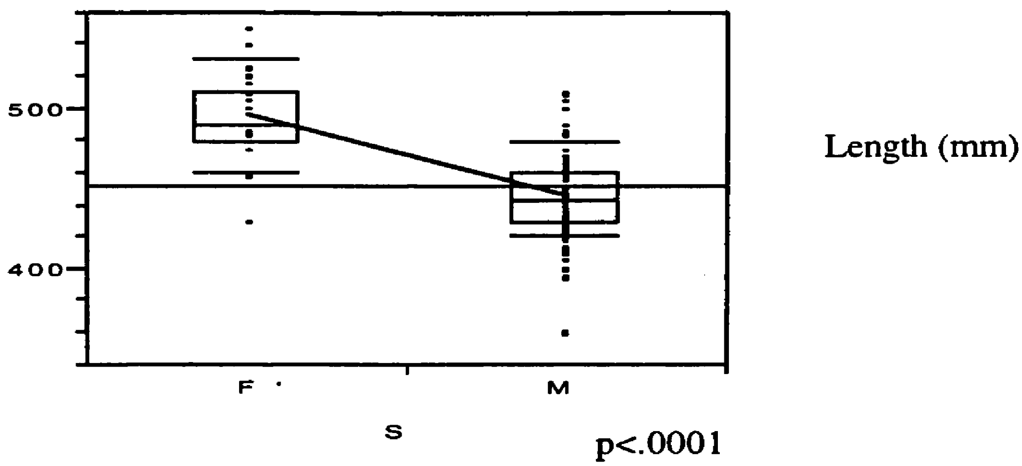
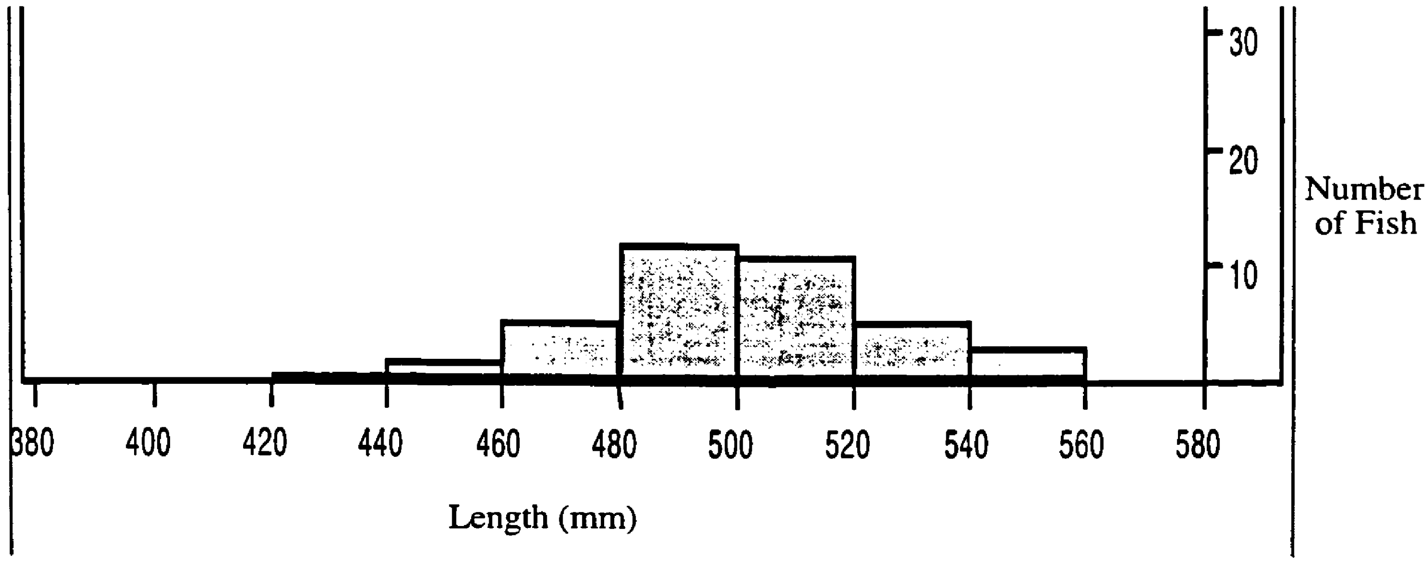


Figure 21.- 1996&1997 length distributions for ripe male and gravid female largescale suckers captured at Milltown dam. Blue line connects means. P value is for t-test comparison of means.



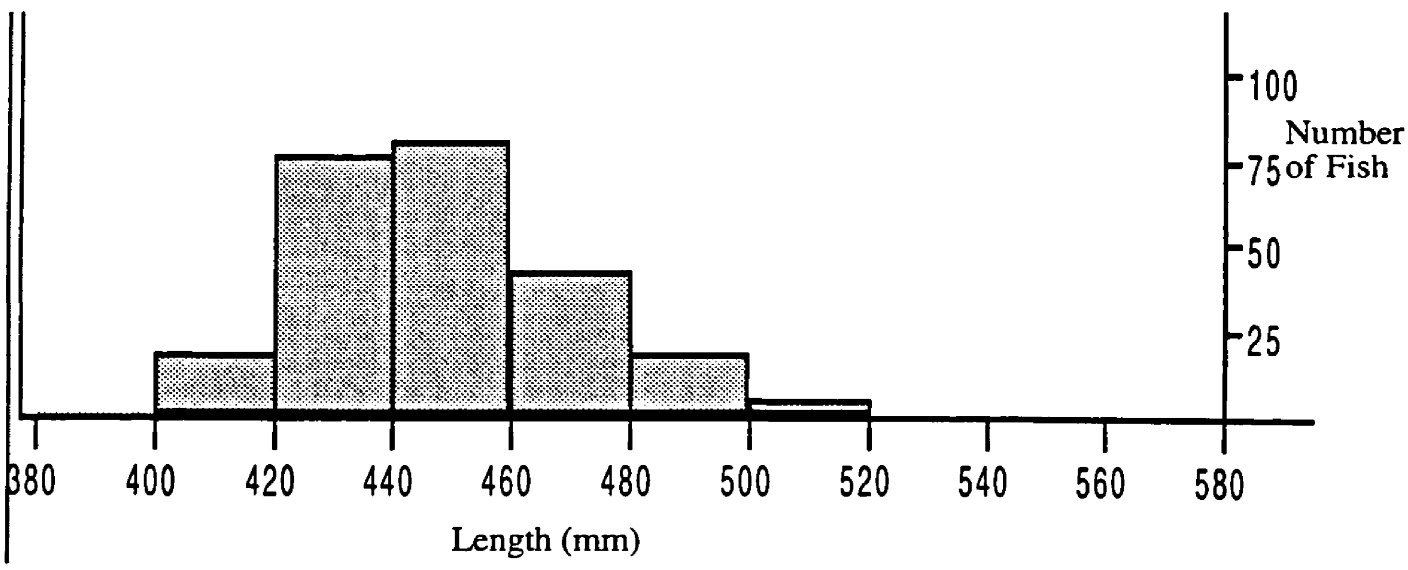


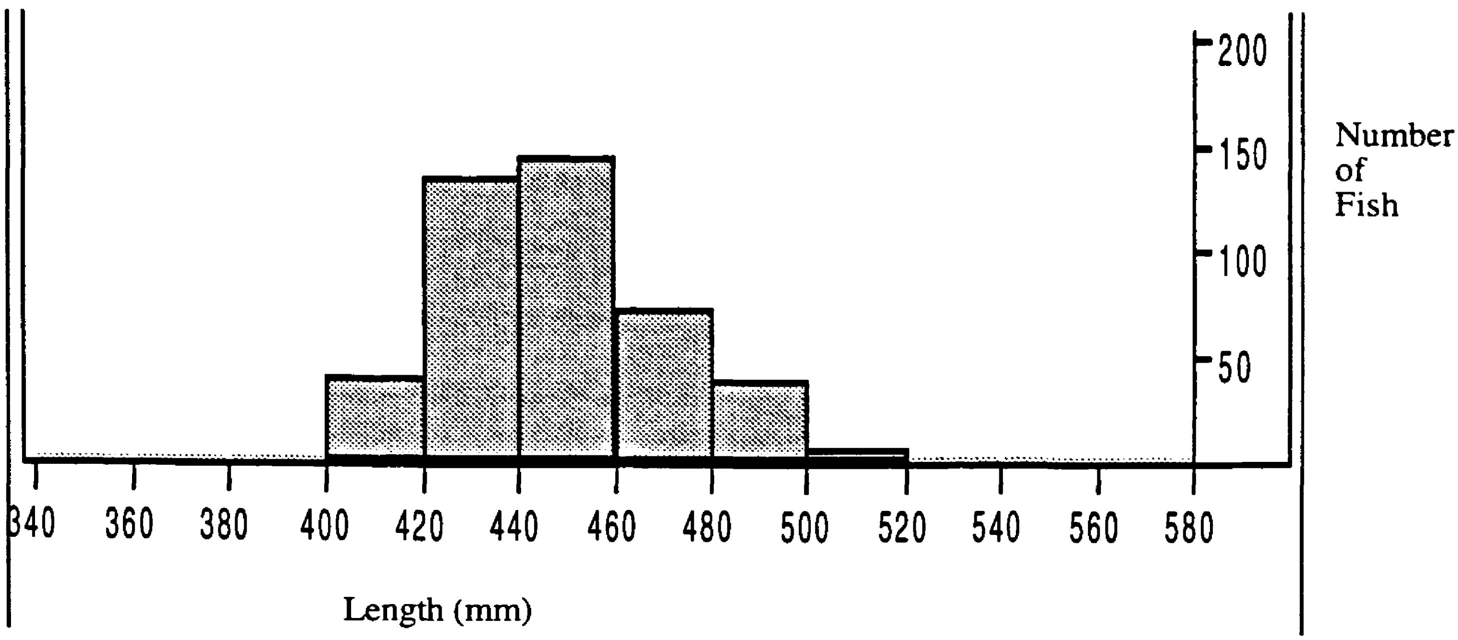
Figure 22.- Length-frequency histogram of gravid females (top) and ripe males (bottom) captured at Milltown Dam in 1996 and 1997.

Male to Female Ratio

In 1996 and 1997, the ratio of male to female largescale suckers at Milltown Dam was 1:1.35. There were no changes in this ratio during three months of surveys in 1996 or during three months in 1997 (ANOVA. $p = .632$).

Spawning Population Size Structure

Female largescale suckers captured at Milltown Dam were significantly larger than male largescale suckers captured at the dam (471 vs. 445 mm. t-test, $p<.0001$) . Male largescale suckers over 500 mm are not well represented in the length-frequency histogram (Figure 23.)



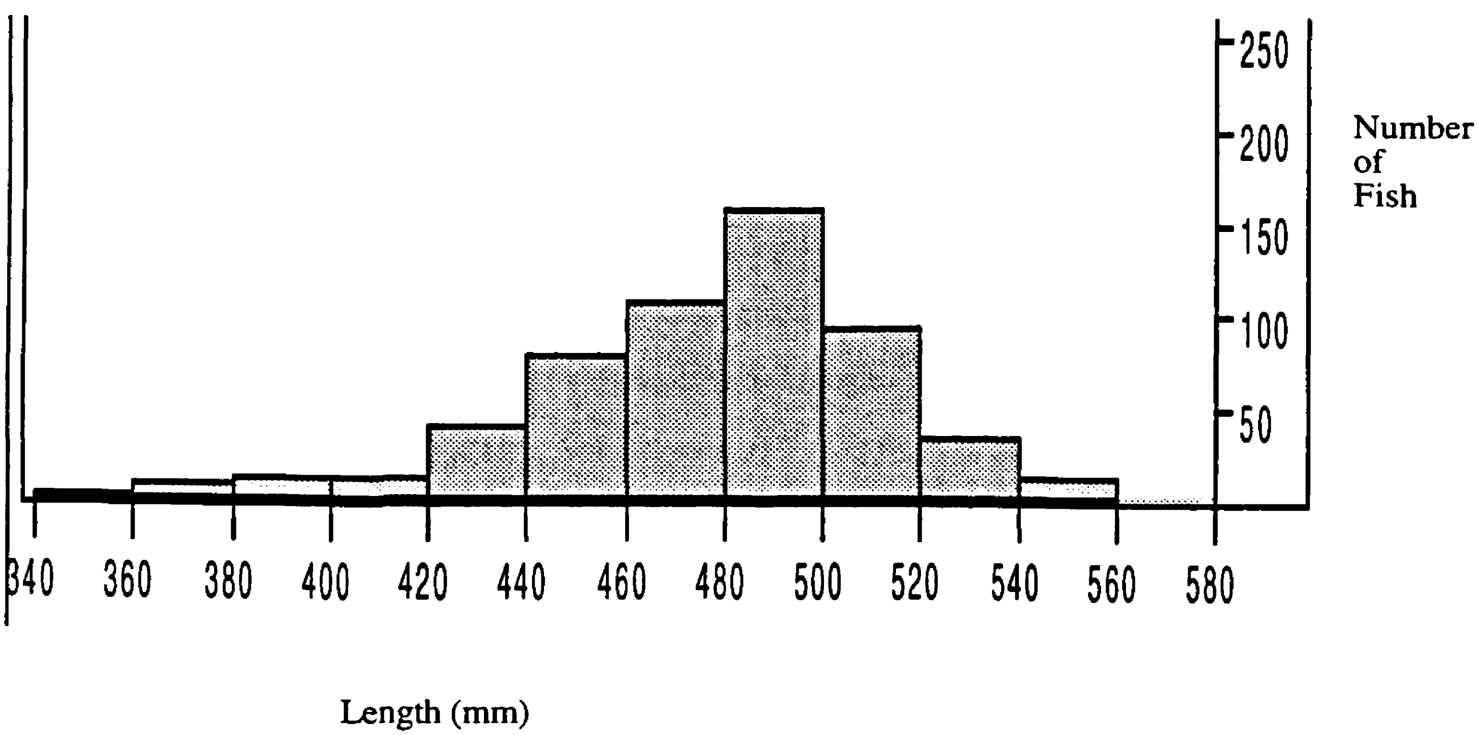


Figure 23.- Length-frequency histograms of male (top) and female (bottom) largescale suckers captured at Milltown Dam in 1996 and 1997.

Male largescale suckers with transmitters that migrated to Milltown Dam were significantly smaller than males with transmitters that did not migrate (Figure 24). Average length of males that migrated to the dam (n=3) was 446 mm, which is not significantly different than mean length of spawning largescale suckers collected at Milltown (445 mm) (t -test, p=.772). The mean length for non-migrating males was 508 mm, which is significantly larger than the average spawning male collected at the dam (p<.0001). By contrast, there were no significant differences in lengths of migrating and non-migrating female largescale suckers.

Mean size for gravid largescale sucker females was significantly larger than the mean size of the overall female population captured at the dam (496 mm Vs 469 mm. t-test. p<.0002) (Figures 25, 26). In contrast, ripe male largescale suckers captured at the dam were not significantly different in size from the overall male population at the dam (447 mm vs. 445 mm. t-test. p>.5686) (Figures 25, 27).

Percent Ripe Male and Gravid Female Largescale Suckers

In both 1996 and 1997, the highest percentage of males were ripe immediately following the peak in the hydrograph. On June 27, 1996, 74% of largescale suckers captured at Milltown Dam were ripe. On July 2, 1997, 91 % of males captured were ripe. High water prevented repetition in sampling plans in the two years (Figure 28).

The percentage of females gravid during any one sampling period was low throughout 1996 and 1997. In 1996, this percentage was below 10% and did not vary significantly from March until July. In 1997, significant trends were observed. On May 24, 32% of females were gravid, which was significantly more than on either April 15 (7%) or July 10 (11%).

There were no significant trends in sizes of gravid females during either years (ANOVA, p=.72). There were no statistically significant differences in lengths of ripe males captured over the course of sampling in either 1996 or 1997 (ANOVA, p=.58)

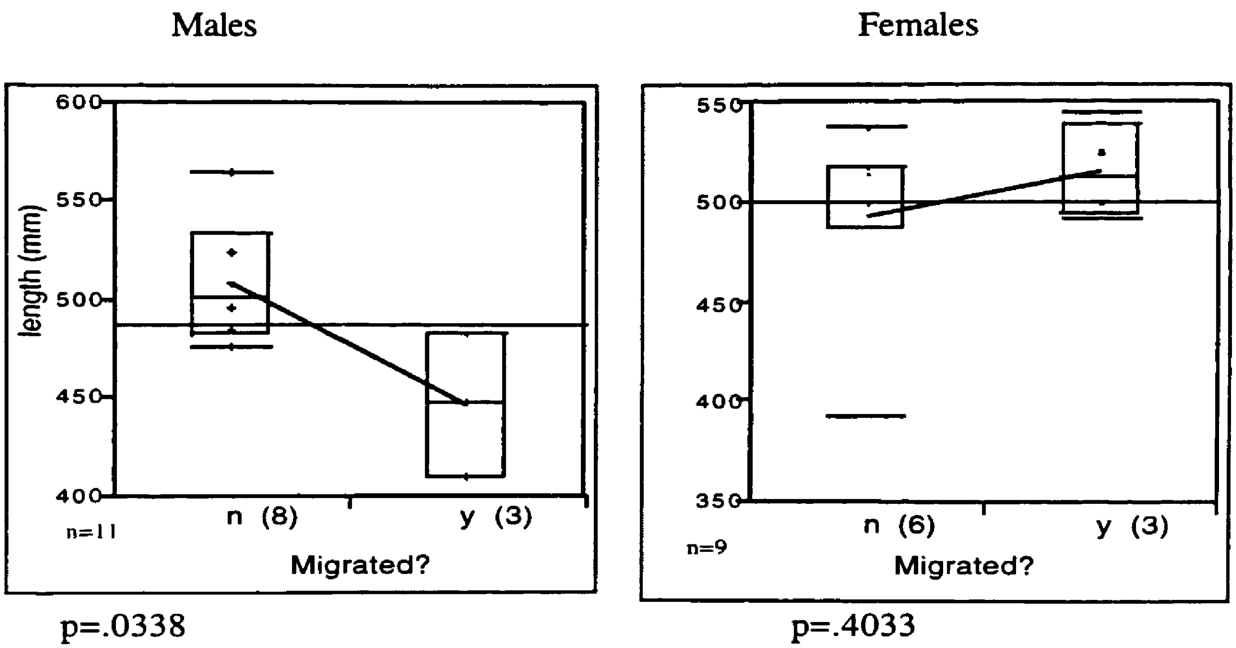
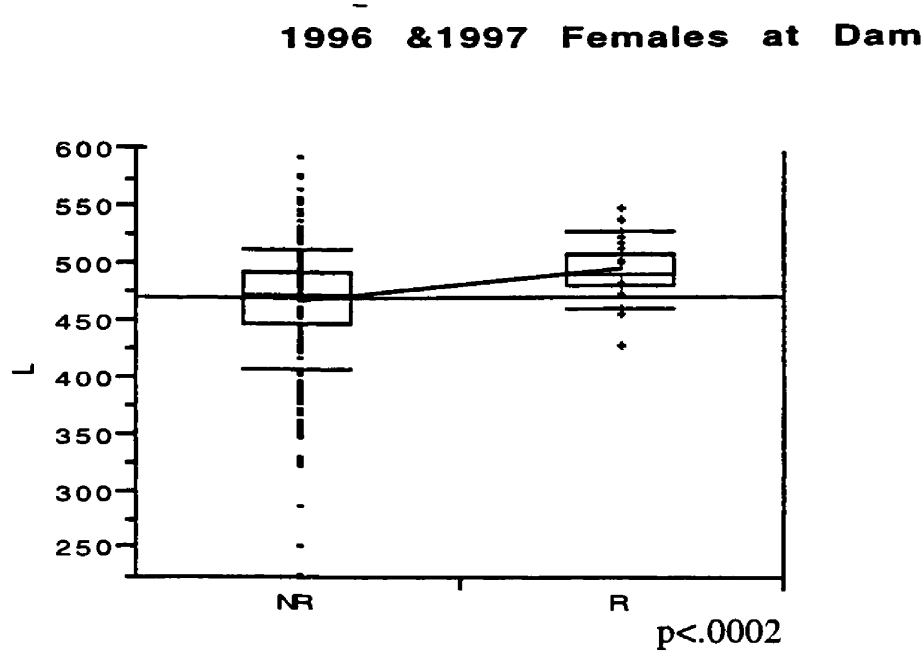


Figure 24. Comparison of lengths of migrating and non-migrating male (left) and female (right) largescale suckers with radio transmitters. P values are for t-tests of means.



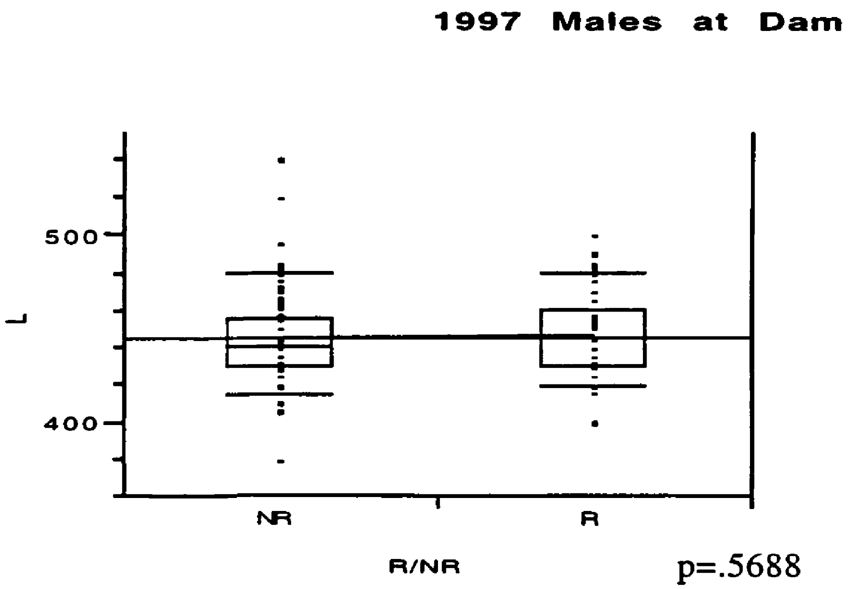


Figure 25.- Comparison of lengths for ripe (R) and not-ripe (NR) female (top) and male (bottom) largescale suckers captured at Milltown Dam in 1996 and 1997. P values are for t-tests of means

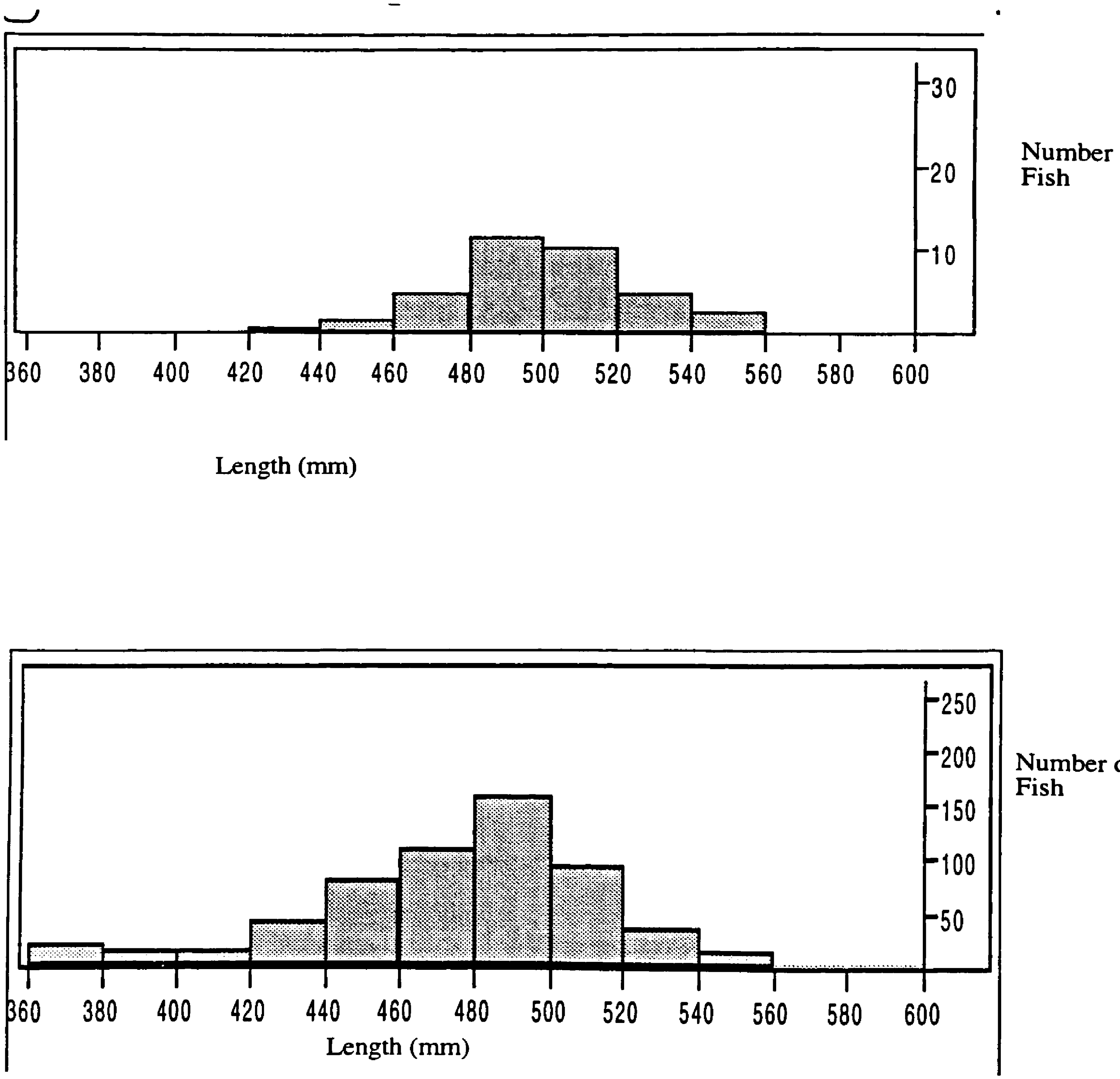


Figure 26.- Length- frequency histogram of gravid (top) and all (bottom) females captured at Milltown Dam in 1996 and 1997.

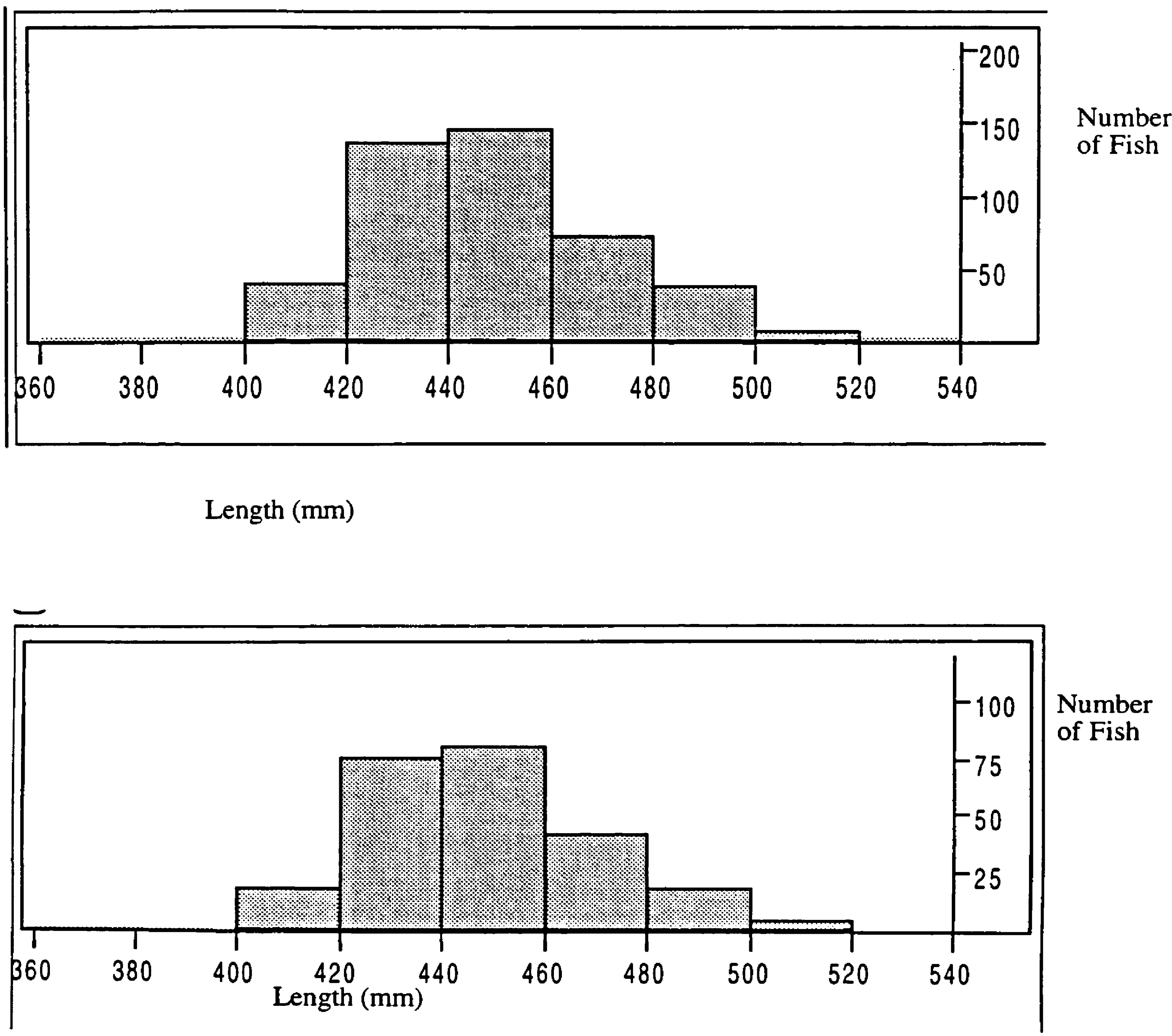


Figure 27.- Length-frequency histograms for non-ripe (upper) and ripe (lower) male largescale suckers captured at Milltown Dam.

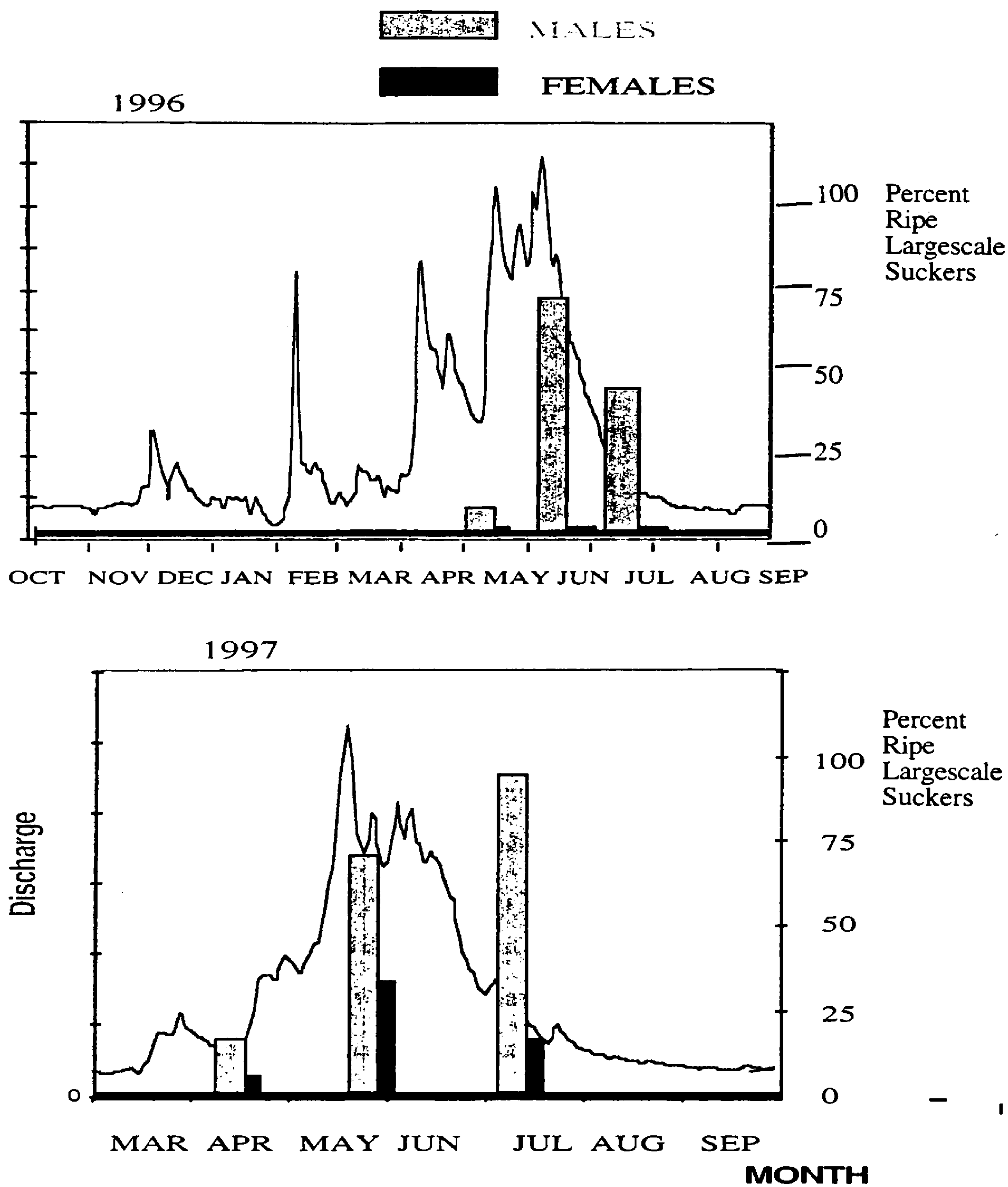


Figure 28.- Date of capture, percent ripe male (blue bars), gravid female (black bars) largescale suckers and hydrograph for 1996 (top) and 1997 (bottom).

Sexual Dimorphism

Female largescale suckers were larger than males. Males possessed tubercles on the lower lobe of the caudal fin, the last three to four rays of the pectoral fin, and the anal fin. While these tubercles were larger in May and June than at other times of the year, they were very apparent in male largescale suckers captured in October and November. Males were also distinguished from females by an elongated lower caudal fin lobe and an elongated anal fin. In addition, the ventral surface of male largescale suckers in May and June was noticeably rough to touch. As water temperatures rose above 11 C, most largescale suckers captured had dark coloration on their dorsal sides. This was present in both sexes but was more apparent in males than females.

Daily Temperature, Discharge And Movement

The numbers of largescale suckers that entered the radial gate pool at Milltown Dam corresponded with mean water temperature, and not with discharge, during that 24 hour period (Figures 29, 30, 31 and 32). The first 284 largescale suckers moved into the radial gate pool on March 23, 1998, with water temperatures of 6.5 C. From March 27 to April 1, water temperature dropped below 5 C, and no largescale suckers entered the radial gate pool. On April 3, water temperatures rose to 9 C and 1010 largescale suckers were captured. From April 8 until April 17, water temperatures dropped below 7 C and no fish were captured in the pool. On April 17, water temperatures rose to 7.5 and 94 largescale suckers were captured in the pool. On April 20, water temperatures reached 9 C and 900 largescale suckers were captured in the pool. On April 22, water temperatures reached 11.5 C. Approximately 6,000 largescale suckers entered the pool. Due to time constraints, only 2000 largescale suckers could be counted and observed for marks. I estimated that 3000-4000 largescale suckers remained in the radial gate pool at the end of the day.

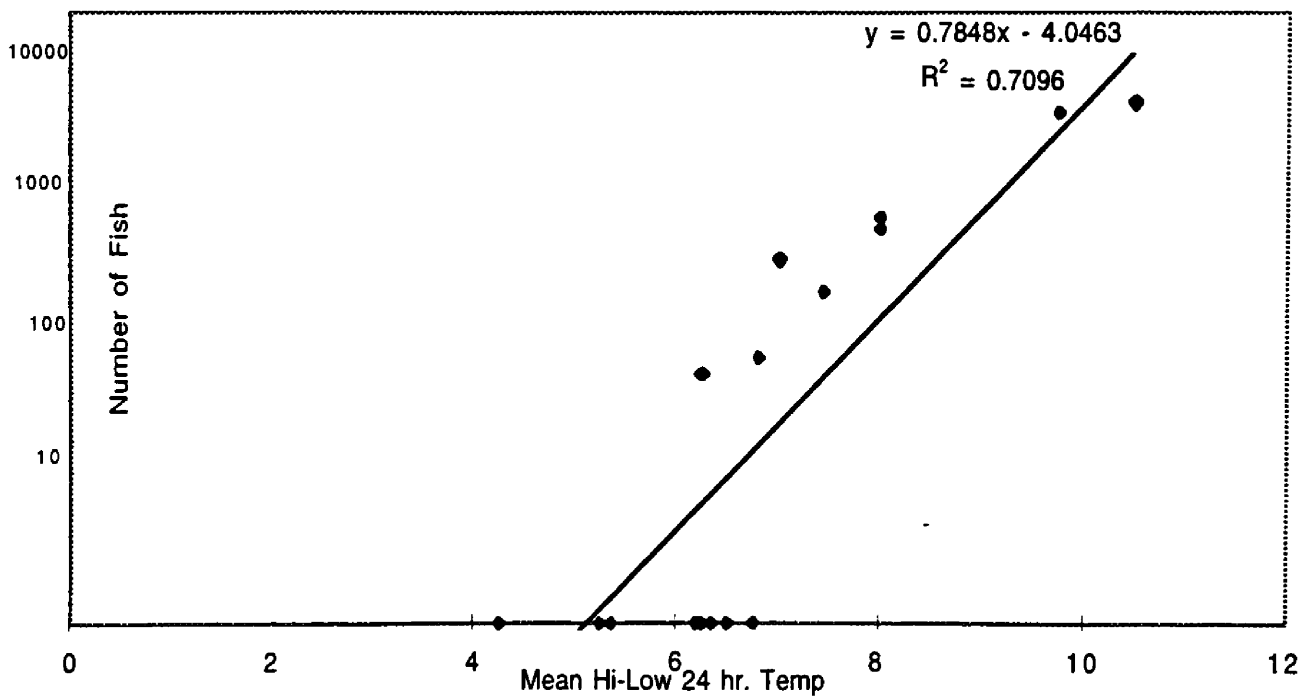


Figure 29.- Linear regression of numbers of largescale suckers captured during 24 hours in the radial gate pool, and the mean water temperature during that period.

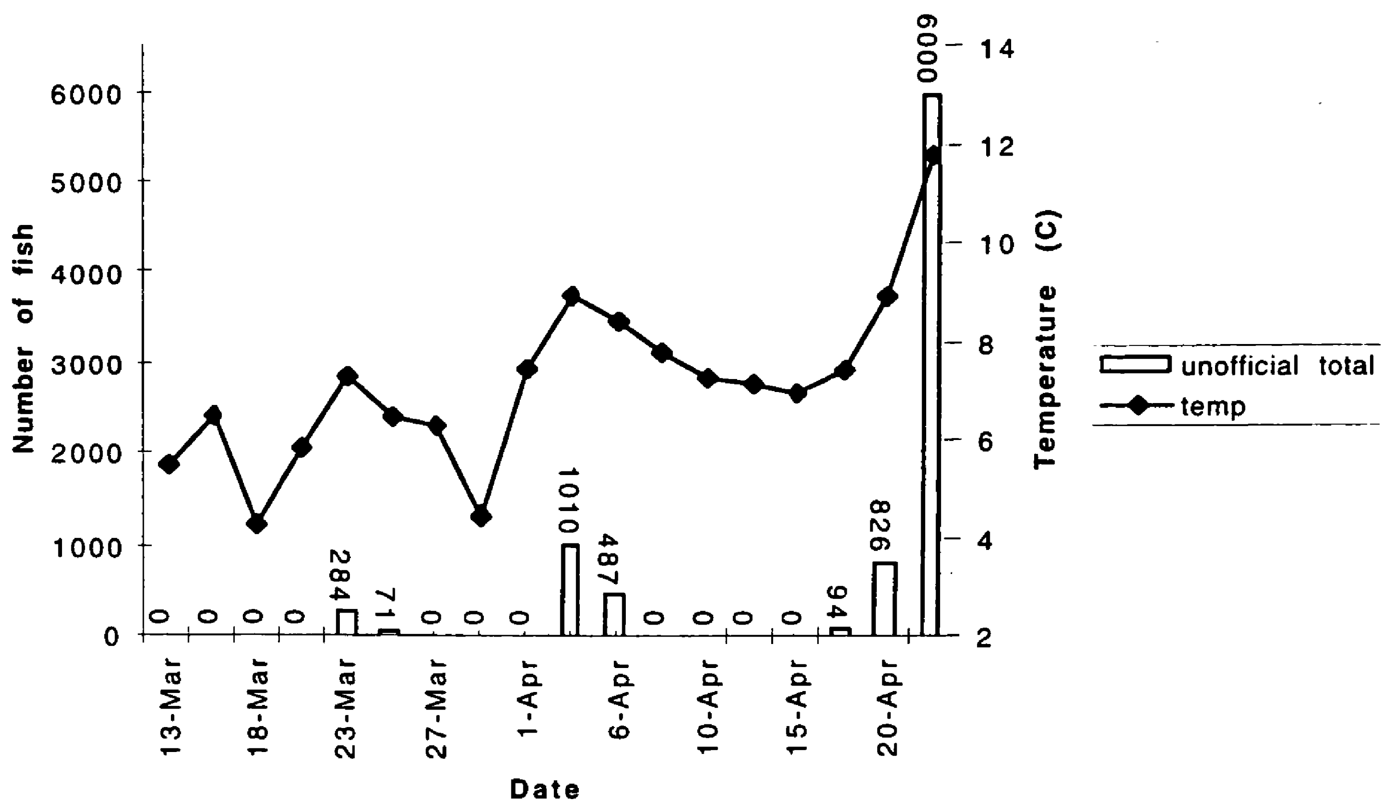


Figure 30- Number of largescale suckers captured during 24-hour period and water temperature at Milltown Dam radial gate.

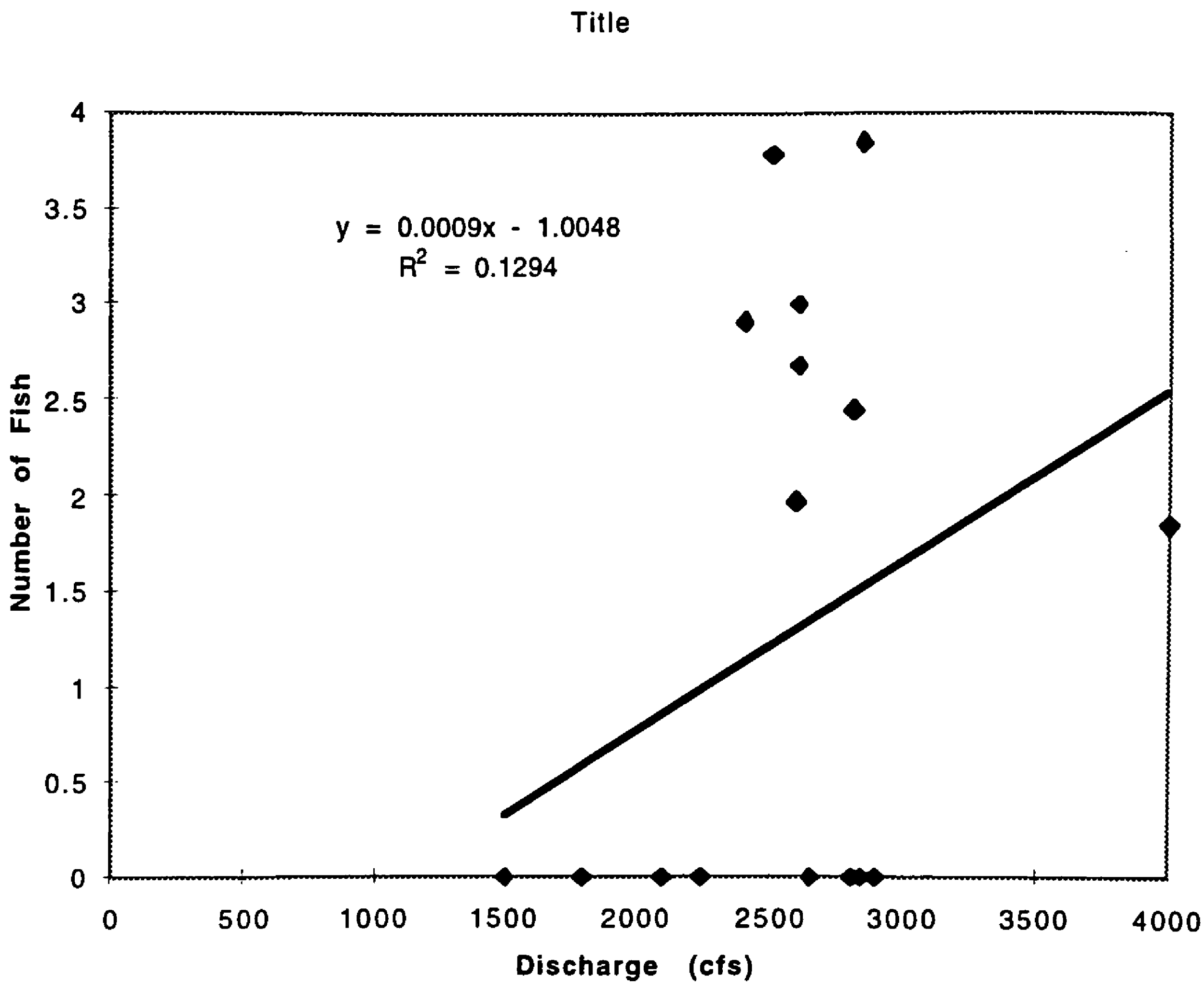


Figure 31.- Linear regression of number of largescale suckers captured during 24-hour period and river discharge at Milltown Dam.

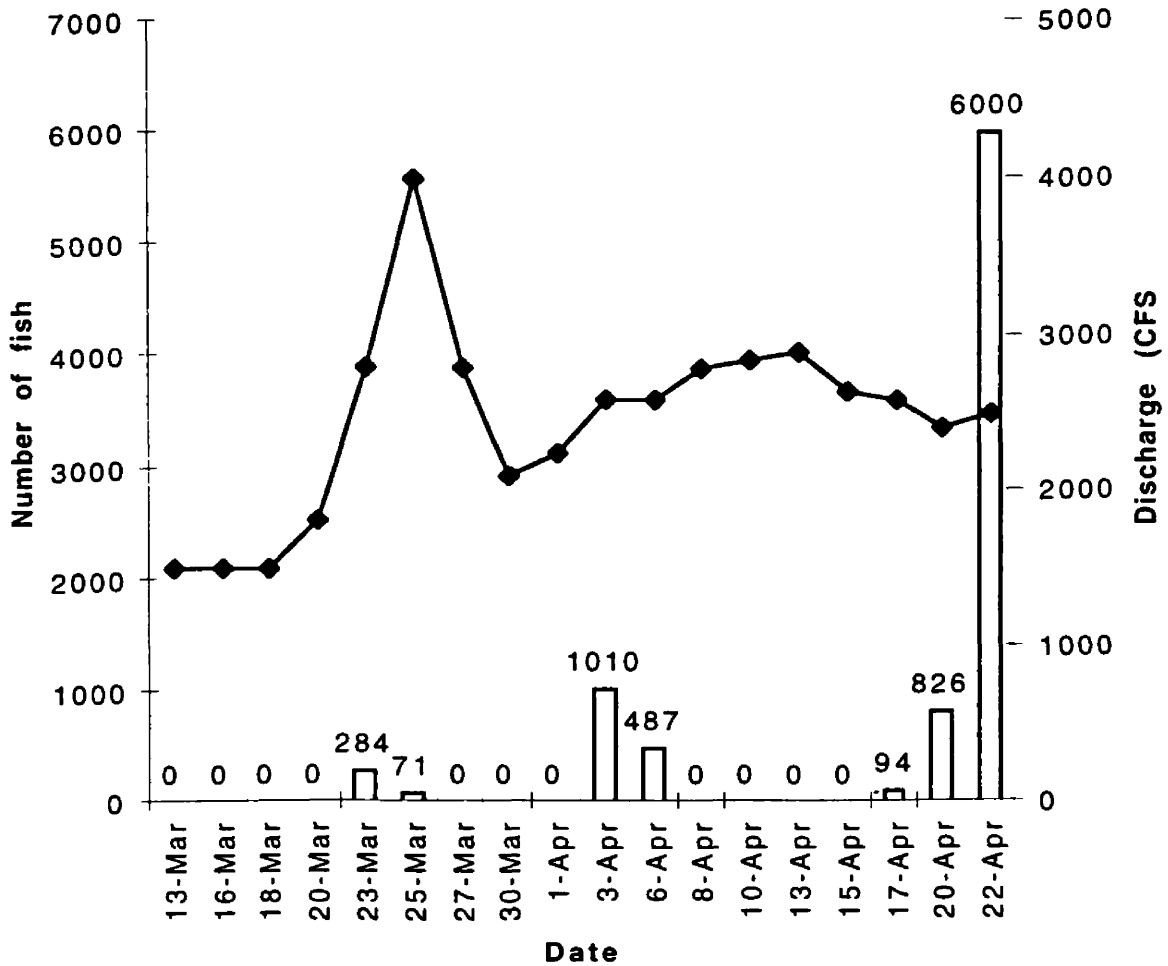


Figure 32- Number of largescale suckers captured and river discharge at Milltown Dam radial gate.

Observations from the Dam

Largescale suckers climbed the apron throughout the day as water temperatures rose above 7 C. In 1997 and 1998, largescale suckers were found moving onto the apron in shallow (5 cm) water and remaining motionless, on the apron, for five to 15 minutes. These largescale suckers were easily approached on foot and would not move until touched. At water temperatures above 11.5 C approximately 300 largescale suckers remain on the apron at any one time.

In 1997 and 1998, at water temperatures above 11 C, numerous largescale suckers began what can best be described as jumping. Typically only the head and dorsal surface broke the water surface. This occurred throughout the pool downstream of the dam but did not occur when largescale suckers were collected in the radial gate pool and water flow was stopped.

In the mornings at Milltown, great blue herons were frequently standing on the apron as largescale suckers swam on the apron. Herons were also found in the radial gate pool as we arrived at the dam in the mornings. Largescale suckers were found with large, cylindrical wounds on their sides throughout the sampling period. In addition, osprey were often observed flying above the largescale suckers as the fish climbed the apron. However, osprey were observed capturing only small salmonids.

Discussion

Spawning Migrations and Influence of Milltown Dam

Milltown Dam has prevented upstream passage of fish in the Middle Clark Fork River for 90 years. In 1998, approximately 44,000 largescale suckers attempted to swim upstream of the dam during their spring spawning migrations. Downstream migrations of these fish later in the year suggests that some largescale suckers moved in excess of 100 km to reach the dam that spring. The distance of this movement has not been observed before in largescale suckers. Dauble (1986) recorded maximum movements of 60 km in the Columbia River, WA. Coupled with the quantity of fish attempting to climb the dam each spring, the distance of these migrations suggests that the influence of Milltown Dam on this native species is significant and extends well beyond the physical structure itself. The biological significance of these impacts remains uncertain.

Use of post-spawning, downstream movements to infer distance of pre-spawning, upstream migrations is somewhat speculative and must be justified. While phylogenetically similar white suckers (McCart and Aspinwall 1970) return in successive years to the same spawning streams (Olson and Scidmore 1963; Werner 1973), no data exist suggesting whether catostomids in general and largescale suckers in particular return to the origins of their migrations after spawning. However, Swanberg (1996) found that, after spawning, bull trout returned to within meters of the origin of their migrations. Data from this report in 1997 demonstrates that at least some largescale suckers return, after spawning, to their pre-spawning locations. All six largescale suckers with transmitters that made identifiable spawning migrations in 1997 returned after these migrations to within 200 meters of their original locations. It does appear reasonable to suggest that largescale suckers that moved

100 km downstream after spawning had made similar upstream migrations prior to spawning.

Other data from downstream migrations in 1996 suggest that many largescale suckers that migrate to Milltown Dam began their migrations near Kelly Island, 14-17 km downstream of the dam. While it is not possible to extrapolate from a small sample to a large spawning population, 10 of 16 largescale suckers with transmitters implanted in 1996 moved downstream to Kelly Island and remained there throughout the following year.

Onset of Spawning Migrations

In 1996, 1997 and 1998, largescale suckers began climbing the Milltown Dam apron on March 13, 16 and 23, respectively. Water temperatures on these days in 1997 and 1998 were 5.5 and 6.5 C. In 1997, the first largescale sucker with a radio transmitter began its spawning migration to Milltown Dam on March 25. These temperatures are significantly lower than observed by Dauble (1986), who found movement beginning at 10 C. Data from 1998 suggests rises in water temperature above 6.5 C, rather than discharge, trigger movements. Kolok et al. (1994) measured significant increases in both swimming performance and cardiac output in largescale suckers held in water temperatures between five and 10 C, and maximum efficiency occurred above 10 C. At temperatures above 11 C, 6,000 - 7,000 largescale suckers would move into the radial gate pool over 24 hours.

Four of the twenty fish captured in 1997 near Kelly Island made migrations to Milltown Dam. The low percentage (20%) of migrating fish agrees with Quinn and Ross (1985) and Geen et al. (1966), both of whom found non-annual spawning in white suckers, but may also result from changes in fish behavior and activity due to the transmitter itself. However, Matheney and Rabeni (1996) observed no differences in behavior with northern hog suckers implanted with transmitters. In observations of largescale suckers in the shallow and clear Rattlesnake Creek, I was able to detect no difference in movement or activity of implanted largescale suckers from those without transmitters. Finally, numerous other authors have reported no noticeable effects on fish that are implanted with transmitters (More et al. 1990; Lucas and Frear 1997), even those fish that are implanted while spawning (Young 1996).

The low percentage of migratory fish may also result from the fact that largescale suckers spawn over a wide range of substrates (Dauble 1986) and most likely spawn in areas other than Milltown Dam. For example, McCart and Aspinwall (1970) found largescale sucker spawning in inlets, outlets and within a lake itself all within the same lake system. While this possibility exists, we found no indication of spawning other than the presence of two ripe males at Kelly Island. However, our sampling efforts downstream of Milltown Dam were minimal during high-flows (when largescale suckers spawn).

The intended destination for largescale suckers that migrate to Milltown Dam remains unknown. At least two possibilities exist. The first is that largescale suckers move to Milltown Dam each spring in an attempt to swim into upstream stretches of the Clark Fork or Blackfoot Rivers in which the fish were reared. Olson and Scidmore (1963) found that most white suckers returned to those streams in which they were reared. Werner (1973) demonstrated that white suckers follow olfactory cues to return each year to natal streams. The second possibility is that largescale suckers are not attempting to swim further upstream but instead are returning to Milltown Dam to spawn in its downstream pool. While data from this study suggests that largescale suckers may spawn downstream of the dam, the latter hypothesis does not account for the estimated population of 44,000 largescale suckers that moved into the radial gate and attempted to swim upstream of the dam in 1988.

Some of this uncertainty might be resolved by determining if largescale suckers that move to Milltown Dam appear to select waters from either the Clark Fork or Blackfoot Rivers. At Milltown Dam, flows from the two rivers have not mixed and are often visually distinct (Figure 33).

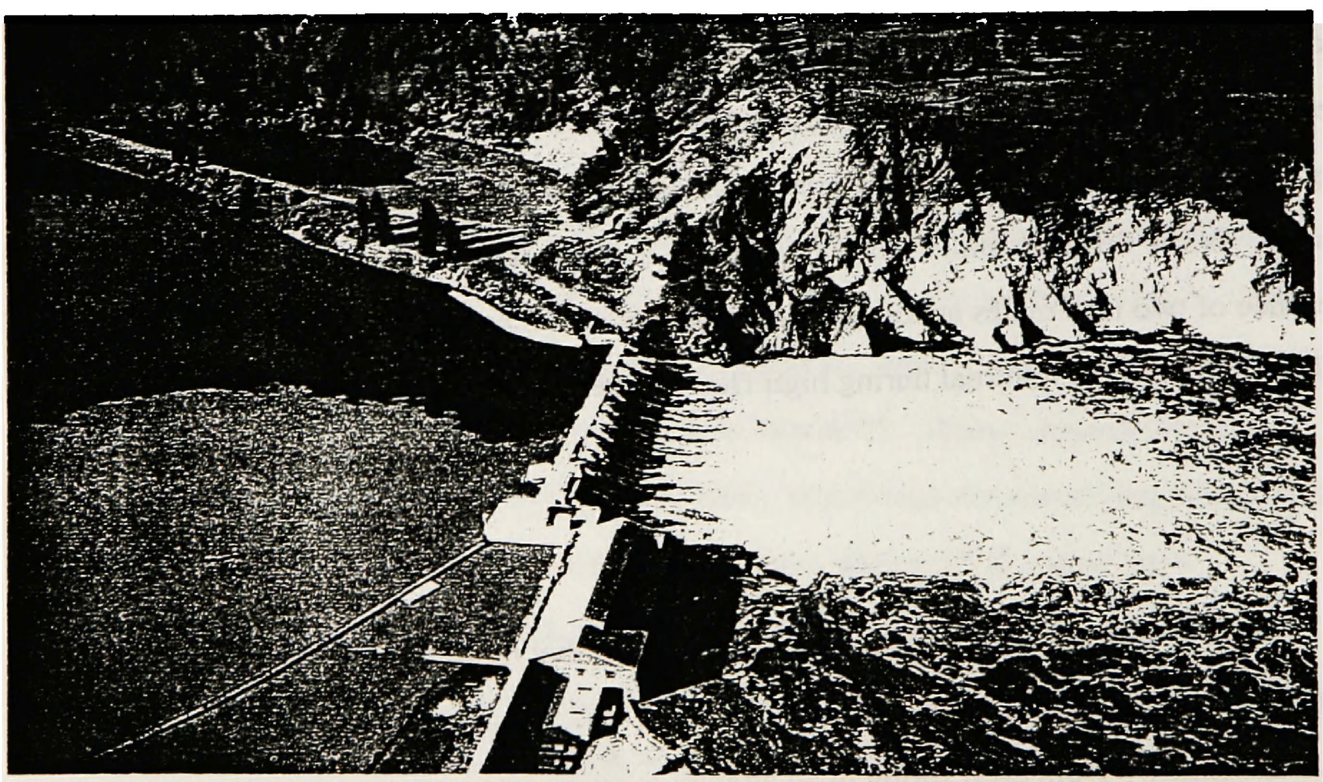


Figure 31.- Aerial view of Milltown Dam. Flows from the Clark Fork River enter from the top of the picture. Flows from the Blackfoot River enter from below.

Selection by individual largescale suckers for either Clark Fork or Blackfoot River waters would suggest intention to continue migrations in those rivers and would further suggest that those particular fish had previously moved downstream through the dam.

Migration Patterns

Unlike many other migrating fish species that only migrate either during the rise (e.g. Atlantic salmon (Jensen et al. 1986)) or decline (e.g. bull trout (Swanberg 1996); Colorado squawfish (Tyus 1990)) of the hydrograph, largescale suckers with radio transmitters began migrations in 1997 during the rising and falling limbs of the hydrograph. None of the five largescale suckers with radio transmitters that made migrations to the Milltown Dam began their migrations during the peak of the hydrograph. Upstream movements near the peak of the hydrograph may be facilitated by use of flooded riparian areas with low water velocities. Both largescale suckers with radio transmitters that were migrating during the peak flows moved into the same flooded cottonwood stand for three to five days. This area, 150 m downstream of the Rattlesnake Creek confluence, was used in previous years by bull trout (Swanberg pers. comm.). Tyus (1990) found similar use of flooded riparian areas by Colorado squawfish *Ptycocheilus lucius* during peak flows. He suggested that those fish species that make long-distance migrations rely most heavily upon these areas to conserve energy for migrations and spawning. Largescale suckers that migrated after the peak flows were not tracked into this area.

Peak flows in 1997 reached 30 - 100 year flood levels in different reaches of the study area (USGS 1998). Whether largescale suckers would use these flooded riparian areas during lower water years is uncertain.

As a result of time spent in these cottonwood stands, the two largescale suckers that migrated earliest migrated at the slowest rate. Those largescale suckers that migrated after the peak flows did not stop for more than one day, and instead continued without cessation to Milltown Dam.

During summer, fall and winter, largescale suckers with transmitters moved only at dawn and dusk. Migrating largescale suckers with transmitters, however, moved at all times of day and night. This breakdown in diel patterns is typical during spawning (Helfman 1993).

Residence at Milltown Dam and Indications of Spawning

There is evidence from both radio telemetry and mark and recapture data that largescale suckers at Milltown Dam attempt to spawn between May and July. While arrival of largescale suckers with transmitters at Milltown Dam occurred over six months (March until August, 1997), four of the five fish departed from the dam within a three-week period, from June 8 until July 3. Water temperatures at this time rose from 10 to 16 C. Dauble (1986) identified water temperatures between 12 and 15 C as optimal for largescale sucker spawning in the Columbia River. On the Columbia, these temperatures occurred between April and July. Similarly, in British Columbia, McCart and Aspinwall (1970) found largescale suckers spawning from May until early June, with water temperatures between 10 and 12 C. They suggested that spawning continued past this period. On the Clark Fork River in 1997, June 8 until July 3 was also the period during which the greatest percentage of male largescale suckers were ripe. In addition, this time period corresponds with presence of eggs in Union Creek (found June 26) in the Blackfoot River. Finally, this period corresponds with the emergence of larval largescale suckers downstream of Milltown three weeks later. Whether largescale suckers successfully spawn at Milltown is unknown. However, regardless of date of arrival, largescale suckers with transmitters remain at the dam and were present when the possibility for spawning is greatest.

Considerable variation in spawning migrations existed within the spawning population. Most largescale suckers appear to spawner non-annually. Only two of 16 largescale suckers that made migrations in 1996 returned to Milltown Dam in 1997. The few Floy ®-tag recaptures at Milltown Dam similarly document non-annual spawning. Non-annual spawning may be energetically advantageous to fish species that make long-distance migrations (Tyus 1990). This variation exists not only within the population but also within certain individuals. In 1996, one female largescale sucker was captured at Milltown Dam in June and implanted with a radio transmitter. The fish remained at the dam for two weeks. The following year, this fish returned to Milltown Dam in August and remained at the dam for five days. This type of individual variability of movement has not been described for largescale suckers before.

Home Range

Largescale suckers did not move significantly during summer, winter or fall. Home ranges for nine of ten largescale suckers with radio transmitters were restricted to one pool-riffle sequence. Net upstream and downstream movement was limited to 200 - 300 meters. This agrees with other studies of catostomid movement. Matheney and Rabeni (1996) and Legler and Meyers (1988) found that 95% of catostomids in the Ozark River, Missouri, did not move more than one pool-riffle sequence during the year. The unusually large movements of one largescale sucker during the summer and fall may have been due to variation within a large population. Northcote (1992) stated that, within trout populations, there is typically a small, highly mobile fraction and a larger, sedentary fraction. Similarly, Funk (1955) found that within populations of 14 warm-water fish species in Missouri Rivers, there were large segments of the population that were sedentary and smaller segments that moved extensively throughout the stream. However, it also appeared that this particular fish attempted to move upstream past a newly constructed weir in the river, and, being unsuccessful, moved around the weir during the summer.

Feeding Movements, Diet and Competition

Evidence that largescale suckers moved into Rattlesnake Creek to eat mountain whitefish eggs is equivocal. In 1996, the pattern appeared clear. No largescale suckers were observed in the creek before the fall season. Comparative densities of the two species suggested that largescale suckers moved into the study section in anticipation of the mountain whitefish spawn. Largescale suckers fed on mountain whitefish eggs. All largescale suckers moved out of the creek after the mountain whitefish spawn concluded. Data from 1997 was not as clear. In particular, the data does not suggest that largescale suckers moved into Rattlesnake Creek in anticipation of mountain whitefish Although largescale suckers again fed on mountain whitefish eggs, largescale suckers were observed in Rattlesnake Creek throughout the summer and fall of the year. Again, however, all largescale suckers left Rattlesnake Creek at the conclusion of the mountain whitefish spawn. Changes in the hydrograph between the two years may explain some of the discrepancy. Although not measured, flows in Rattlesnake Creek in 1997 were significantly higher than they were in 1996, providing deeper pools throughout the summer and fall of 1997 than were available in 1996.

In addition to identifying another possible cause for movements of largescale suckers, this study documents largescale sucker predation on salmonid eggs. Many studies have documented similar predation by white suckers (See Holey et al. 1979, for a review). Published reports of largescale suckers preying on eggs are fairly minimal. Miller and Beckman (1996) reported largescale sucker predation on white sturgeon in the Columbia River, but importantly noted that hydroelectric impoundment of the river made the sturgeon eggs vulnerable to this predation. Carl (1936) reported largescale sucker predation on kokanee eggs and recommended extirpation of the (sucker) species. Dauble (1986) found little evidence of egg predation, and in fact found no chinook salmon (*Oncorhynchus tshawytscha*) eggs in gut samples taken from largescale suckers collected near spawning chinook. Similarly, both Barbour (1930) and Dence (1948) found white suckers near trout redds during spawning season with no evidence of egg predation. Not surprisingly, McCart and Aspinwall (1970) found largescale suckers feeding on other largescale sucker eggs.

While largescale suckers in Rattlesnake Creek do feed on salmonid eggs, the impact of this predation on mountain whitefish populations is unclear. In the middle Clark Fork River, mountain whitefish share abundances comparable to those of largescale suckers (Peters pers. comm.). Largescale suckers and other catostomids are often implicated in the decline of game fish, either through competition for food (see Marrin and Erman, 1982 for a review; Hayes et al. 1992) or through predation on eggs (Carl 1936; Brown 1966; Schneberger 1972; Minckley 1973). This assumption often results in the removal of catostomids from a watershed when gamefish populations decline (Moyle 1972; Barton 1980). However, many of these assumptions rely upon spurious accounts of competition and predation derived from the evidence of sympatry and diet overlap (Holey et al. 1979; Marrin and Erman 1982) and do not consider that for competition for food to occur, food must be limiting within a system (Fausch 1988; Ross 1991).

A more thorough review of the literature demonstrates that largescale suckers and their eggs are also a common food source for many fish and bird species. In Lake Washington, Beauchamp (1995) reported more largescale sucker eggs in wild steelhead (*O. mykiss*) smolt than any other fish forage. Ironically, Dauble (1986) found mountain whitefish preying on largescale sucker eggs during largescale sucker spawn. Largescale suckers are the primary food source for osprey (*Pandion haliaetus*) in certain rivers in British Columbia (Steeger et al. 1992). Finally, largescale suckers are the primary resident fish source for bald eagles and great blue heron on the Columbia River, WA (Dauble 1986). Writing of the roles of detritivorous fishes in rivers, Bowen (1983) wrote, "simply as a result of their biomass, these few detritivores must play a critical role in the river's energy flux and material cycling and in the population dynamics of their respective communities...and may be responsible for 90% of conversion of plant matter into animal biomass".

Diel Movements

The movements of largescale suckers at dusk and dawn are similar to those described for the northern hogsucker by Matheney and Rabeni (1996). Limited mark and recapture studies have been conducted on diel movements of riverine white suckers (Spoor and Schloemer 1938; Kaveliers 1980; Johnson and Dropkin 1995), but much of the published information on nightly movements of these and other freshwater fish derive from differing night and day catch rates (Emery 1973). White suckers make similar movements from deep pools into shallow riffles at night to feed. Dauble (1986) found higher concentrations of largescale suckers near shore at night and suspected the fish had moved there to feed. Similarly, Matheney and Rabeni (1996) tracked northern hog suckers moving from slow, deep pools into shallow riffles at dusk. However, unlike Dauble, the authors concluded from gut content analysis that northern hog suckers moved into the shallow waters to rest and that feeding was conducted primarily during the day. The possibility of largescale suckers similarly moving into riffles to rest (or at least to minimize energy use *while* feeding), although somewhat counterintuitive, is not without merit. Catostomid body shape, with concave head and ventrally flattened bodies, is well suited for remaining still in shallow, high-velocity water (Matheney and Rabeni 1996). Anesthetized largescale suckers were placed on the inclined apron of Milltown Dam (shallow water with 50 cm/sec velocities) and remained there without support for minutes. Kolok et al. (1994) found that largescale suckers placed in strong currents had no significant increases in cardiac output beyond levels found in largescale suckers held in still water.

Spawning Population

Population Estimate

The estimated spawning population at Milltown Dam is very large. There are some difficulties inherent in this estimate. From telemetry data, immigration is known to occur to Milltown Dam from March until at least June. Immigration would falsely inflate the population estimate by decreasing the proportion of recaptures. In addition, the sampling method selects for behavior: fish must swim into the radial gate pool in order to be captured. It is unknown whether largescale suckers are less likely to return to the pool after being captured and released. Avoidance of the radial gate pool would similarly inflate the population estimate.

However, 4,500 largescale suckers were marked at Milltown Dam during six weeks of surveys. Only 192 were recaptured. When water temperatures rose above 11 C, with 6,000 - 7,000 largescale captured in the radial gate pool, while thousands of other largescale suckers were observed in the downstream pool and on the apron of the dam. The estimate of 33,000 - 55,000 largescale suckers at Milltown Dam does not seem unreasonable. If largescale suckers are non-annual spawners, the fish at the dam represent only a fraction of the adult largescale sucker population in the Clark Fork River from

Milltown Dam to, conservatively, Kelly Island. In addition, the population at Milltown Dam represents only largescale suckers older than three to four years.

Females outnumbered males throughout 1996 and 1997. This agrees with Dauble (1986) who found a sex ratio of 1:1.44 and for Quinn and Ross (1985) who found unequal sex ratios in spawning white suckers. Dauble (1986) suggested that male largescale suckers die after spawning. While death would explain both the unequal sex ratio and the relative absence of larger males in the spawning population, only small male largescale suckers with transmitters migrated to the dam, suggesting that the overall population of male largescale suckers is not well represented in the spawning population.

Conversely, smaller and younger females may migrate to Milltown Dam for several years and not spawn. This is suggested by the comparison of lengths of gravid and non-gravid females. Gravid females were significantly larger than non-gravid females. No females captured at Milltown Dam smaller than 420 mm were ripe. This discrepancy suggests that younger females may migrate to Milltown for several years and not spawn. In contrast, males not only mature at an earlier age but, apparently, most males that migrate to the dam actually spawn. This corresponds with the high percentage of males (90%) that are ripe after the peak of the hydrograph, whereas only 20-40% of the females are ripe at their maximum levels (figure 17). This may also help to explain the observations of McCart and Aspinwall (1970) who found three to eight males per female during reproductive acts despite an unequal sex ratio that favors females to males.

Conclusion

There is significant complexity to movement patterns and habitat use of largescale suckers in the Clark Fork River. Longitudinally, some individuals move in excess of 100 km to spawn, while others do not move out of onr pool-riffle sequence in two years. Laterally, largescale suckers move into flooded riparian areas inundated during peak river discharges. And, on an hourly basis, largescale suckers move at dawn and dusk between slow, deep pools and shallow, high-velocity riffles. Adult largescale suckers in the middle Clark Fork River are large fish in a large population within a large river system. The complexity and extent of this movement perhaps should be expected but is nevertheless surprising for a species that is often considered sedentary. Largescale suckers are often derided for preferring slow, warm and even polluted water. However, this assumption appears to be more a reflection of our own diurnal habits than of largescale sucker movement and habitat use.

The effects of Milltown Dam on this native species extend well beyond the physical structure itself. Milltown Dam stops spawning movements of largescale suckers that have migrated from as far as 100 km downstream of the dam. The dam prevents upstream passage of tens of thousands of spawning largescale suckers each spring. The impact of these effects remain unknown. Spawning largescale sucker populations at Milltown Dam are large. However, we do not have previous population estimates for this area and can not compare the current population with historic populations.

While the presence of whirling disease in the Clark Fork River drainage currently precludes upstream movement of fish over Milltown Dam, in the future such passage may be permitted. If this occurs, movement of largescale suckers and other native, non-salmonid fishes (longnose sucker, northern squawfish, mountain whitefish) must be considered. As the precipitous declines of other formerly abundant species such as the razorback sucker attests, large population numbers themselves do not guarantee the "health" of a species. We are still largely ignorant of the role of largescale suckers within a watershed and need to both study this species further and to encourage its persistence.

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